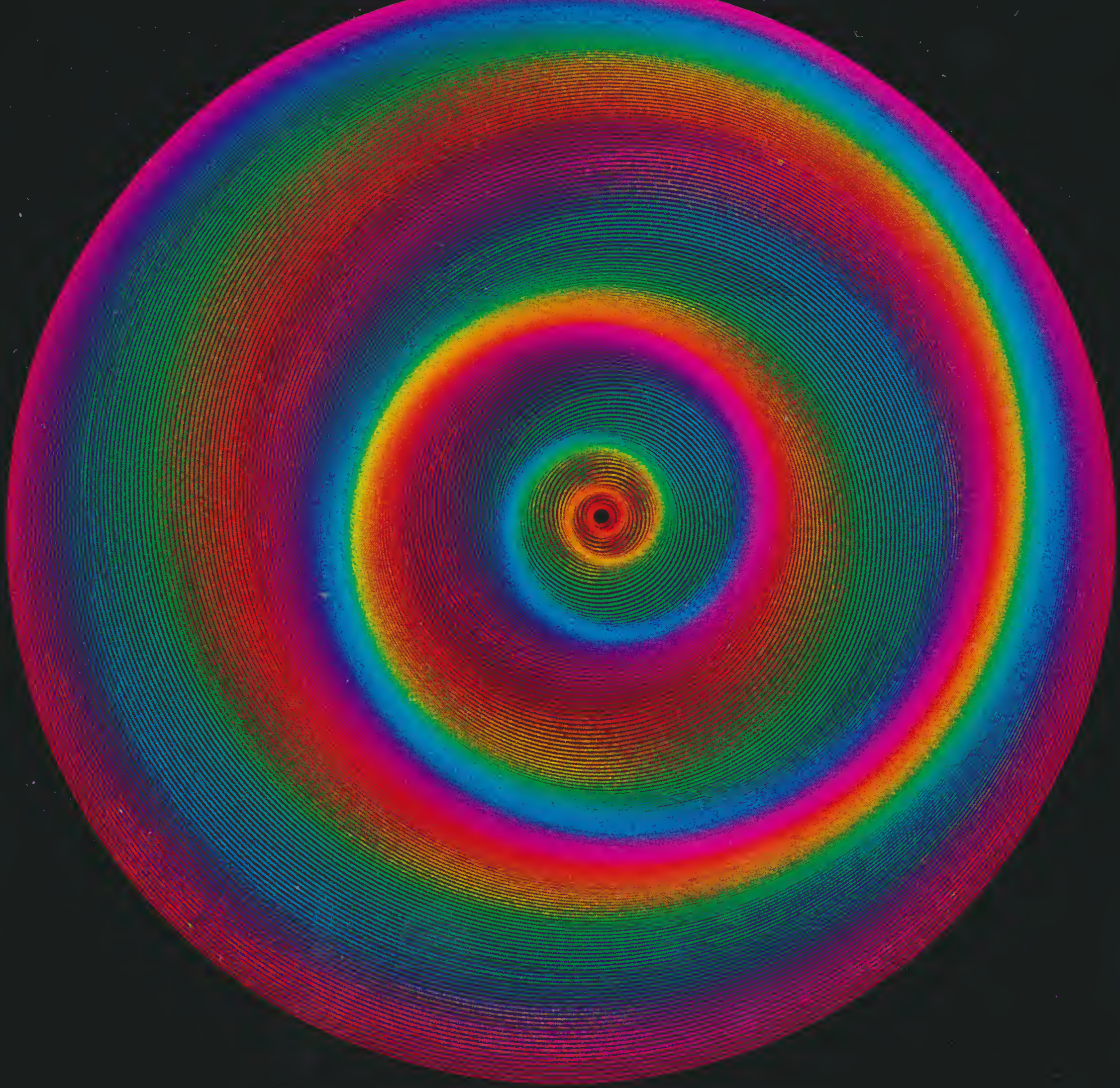


Computer Graphics

Front cover: A computer graphics color system that gives an easily specified range of colors is available to users of LASL's Central Computing Facility. This pattern was generated while experimenting with color variations on circles of varying sizes and positions.

COMPUTER GRAPHICS

What is Computer Graphics?

The eye transmits most of the information acquired by the five senses. We have invented microscopes, telescopes, time-lapse photography, and slow-motion photography to bring out the details of the world around us. Using computer graphics techniques, we can visually examine the structure of the mathematical world. Computer graphics is the generation of precise and reproducible pictures with the aid of a computer.

Points and Lines—The Basic Elements

The computer can produce only points and lines. Computer graphics devices use these basic elements for generating bar charts, data curves, text, or complex pictures. For example, a computer-generated circle consists of numerous, short lines.

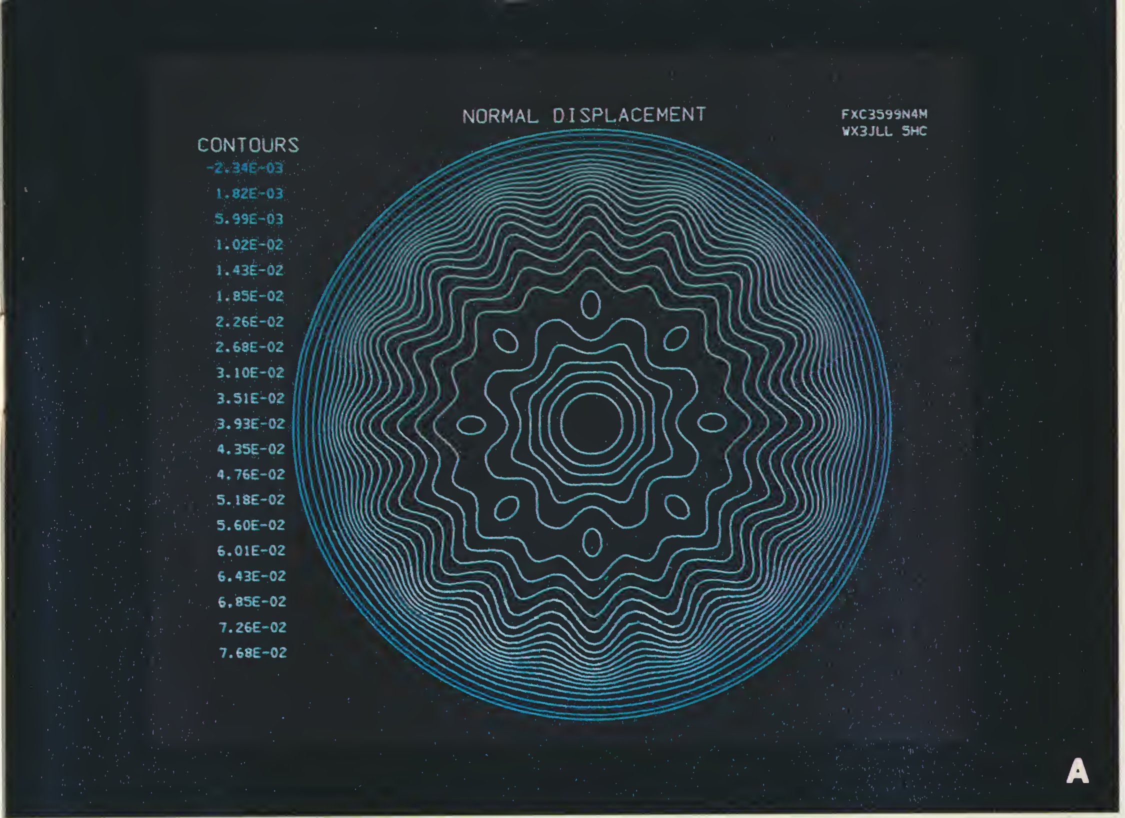
Points and Lines Become Pictures

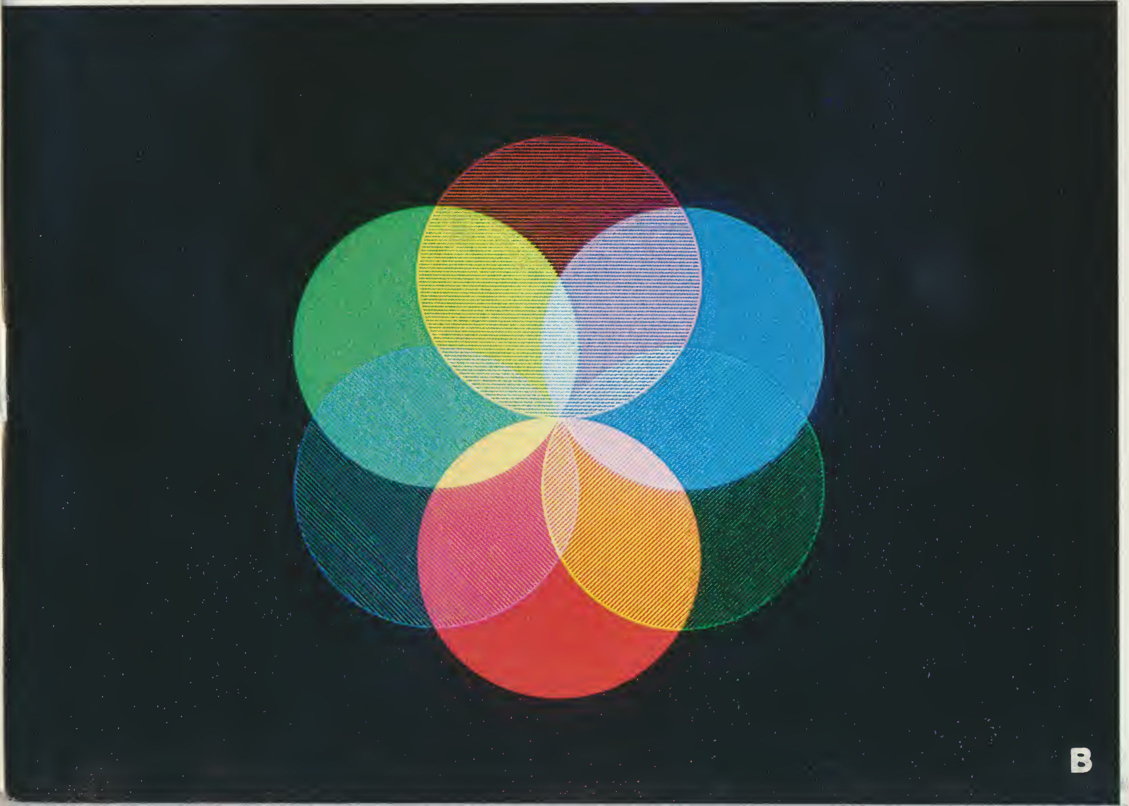
Pictures are created in two ways. In vector graphics, individual vectors, or lines, are combined to form the parts of a picture. This method characterizes most two- and three-dimensional computer graphics images at the Los Alamos Scientific Laboratory (LASL). In raster graphics, the entire picture area is filled with dots of varying intensities, as in a television picture. This second method produces images that closely parallel the realism of a photograph.

The Addition of Color

Points and lines are given the characteristics of width, brightness, and color. In computer graphics displays, the most valuable of these characteristics is color. In fact, in some scientific studies, color is necessary for comprehension.

Color has many advantages. Relationships among components are clearer and easier to understand. Differentiation is possible, such as distinguishing intersecting surfaces. Color is useful in describing the complex intermixing of substances, such as gases. Color is essential for a realistic reproduction of physical features.





A. *A two-dimensional contour plot, used in weapons design studies, reveals deformation of a hemispherical weapon component during a simulated assembly of the weapon.*

B. *A computer graphics "color wheel." Computer graphics produces different colors by mixing red, green, and blue.*

Why Computer Graphics?

Computer graphics increases our ability to assimilate large quantities of information, heightens our perception of the real world around us and any world we can imagine, improves information transfer through accurate and automated publication-quality graphics, and facilitates our interaction with computers through rapid visual updates.

One Picture is Worth More Than a Thousand Numbers

A primary impetus behind computer graphics is the accelerated growth of technical information. Vast quantities of data and complex numerical relationships must be organized into understandable patterns. Computer graphics compresses this information into images that can be quickly comprehended. Colors help to distinguish the various parts of a complex form and simplify the eye's task of detecting small, but important, differences. For some scientific research, many computer graphics pictures are transformed into a motion picture that shows complex, changing phenomena in a comprehensible manner.

To Picture What We Cannot See

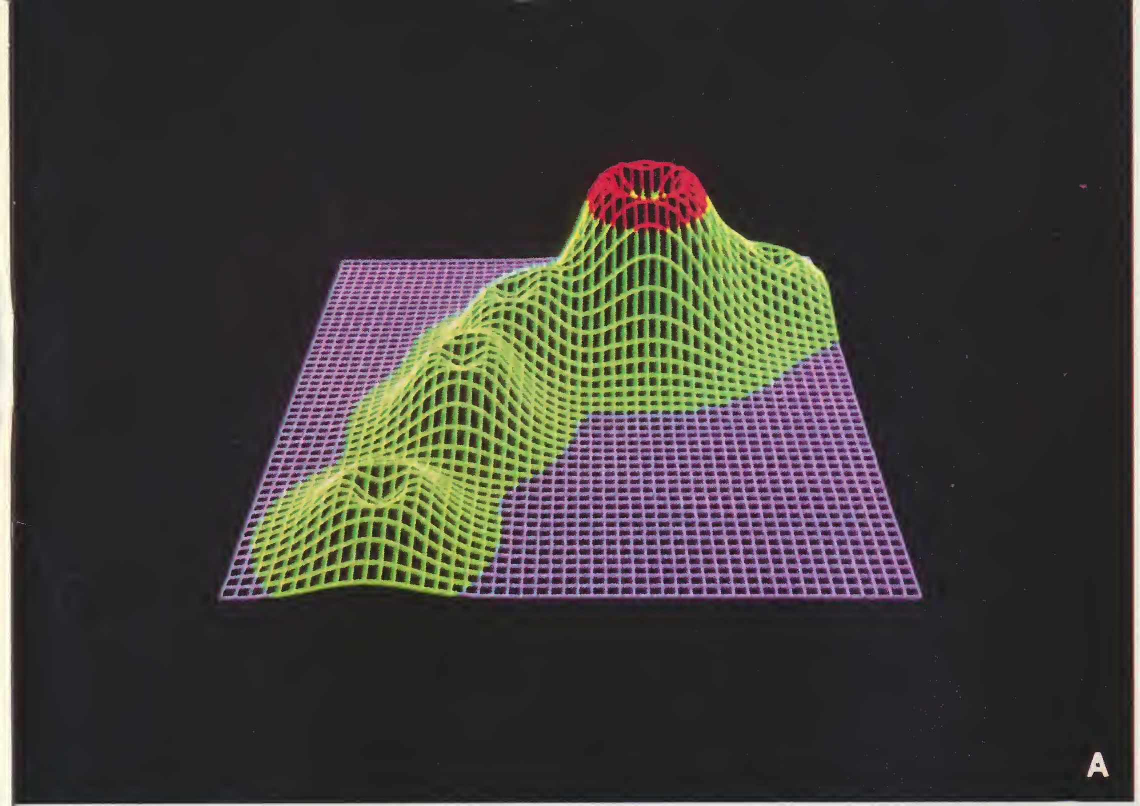
Computer graphics adds new dimensions to our vision. Abstract concepts, such as temperature, pressure, and relationships expressed by mathematical equations, are represented as colored surfaces and volumes. The miniature dimensions of a molecule and the vast distances of the solar system become visible. Time is controlled to slow down an explosion and to speed up geological change. Indistinct features in x-ray and satellite photographs are clarified. New designs for architecture and for mechanical devices are visualized, and the designs are then tested by computer models before they are constructed.

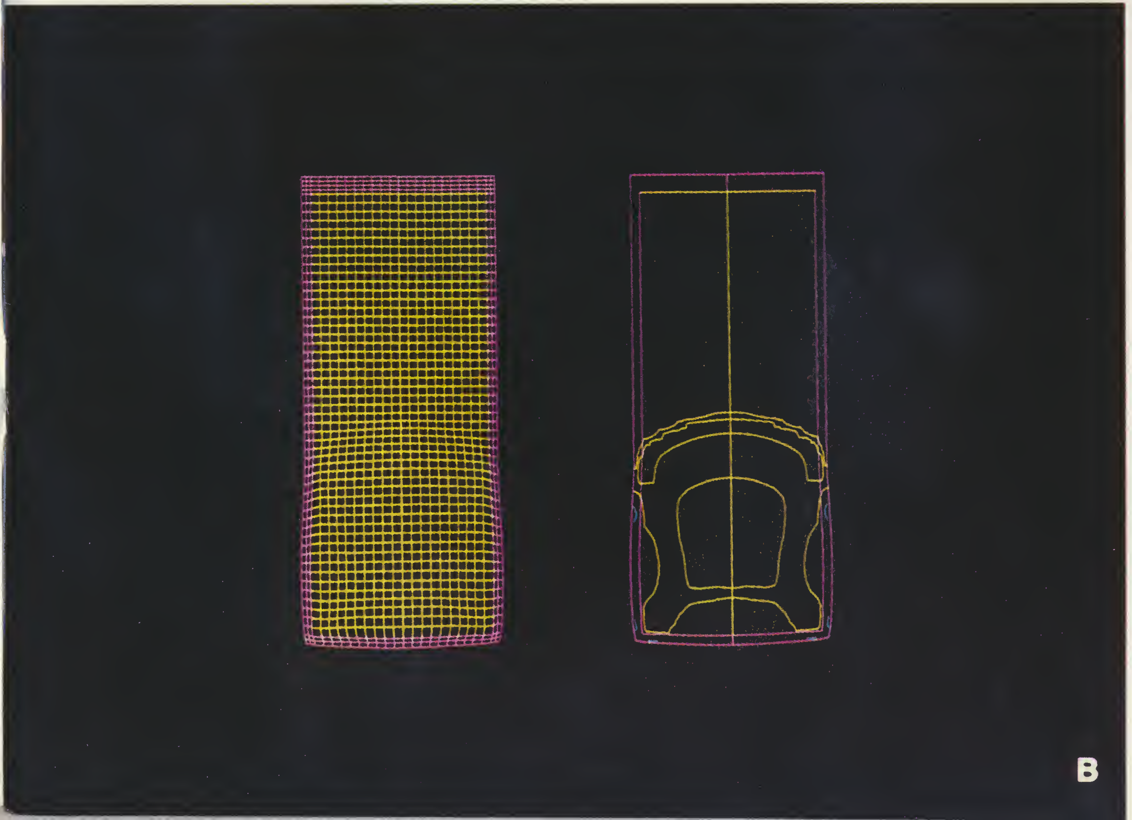
Communication with a Professional Touch

Computers can also generate publication-quality graphics. Complex maps and elaborate three-dimensional drawings are produced quickly and accurately. Entire formal reports—including text, mathematical equations, and drawings—are prepared and easily modified in a reliable, automated fashion.

Painting a Picture a Dozen Ways

Interactive computer graphics enhances direct conversation with the computer. Looking at a television-like screen, a researcher can examine and test several theories in a short time. Data can be updated, a design modified, parts of a picture isolated, or an object rotated to show the other side.





A. *A three-dimensional perspective plot transforms pages of numbers into a chain of volcanic islands.*

B. *These mesh and contour plots display pressure building up within a steel cylinder shortly after detonation of a high explosive. These images are part of a weapons design movie.*

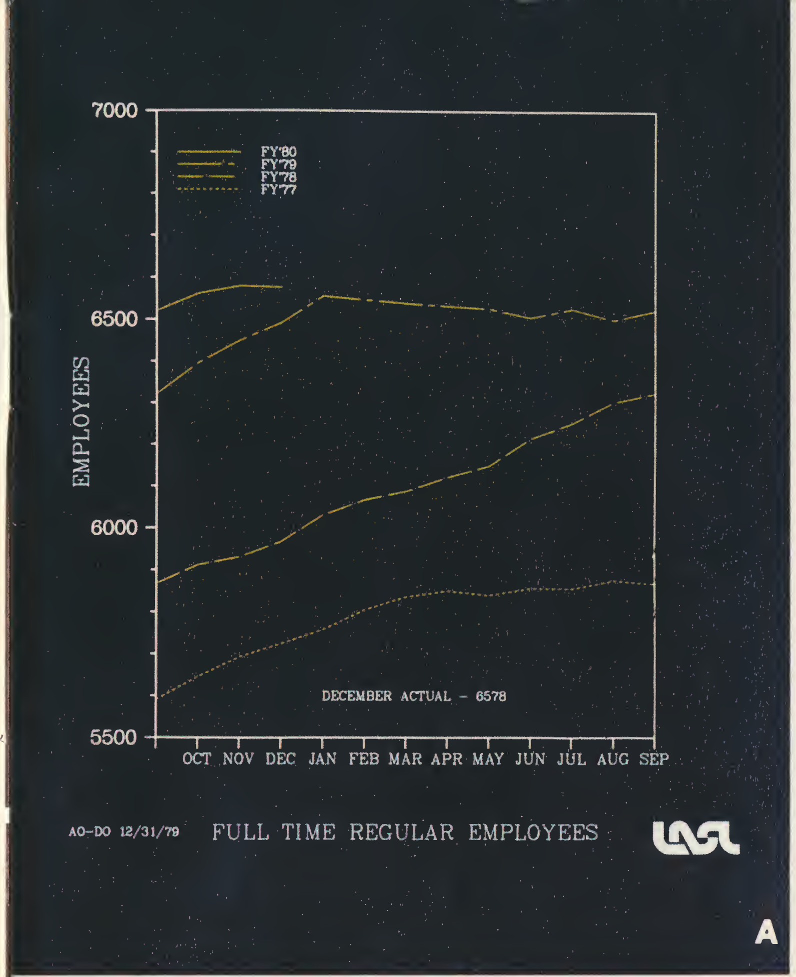
Computer Graphics at LASL

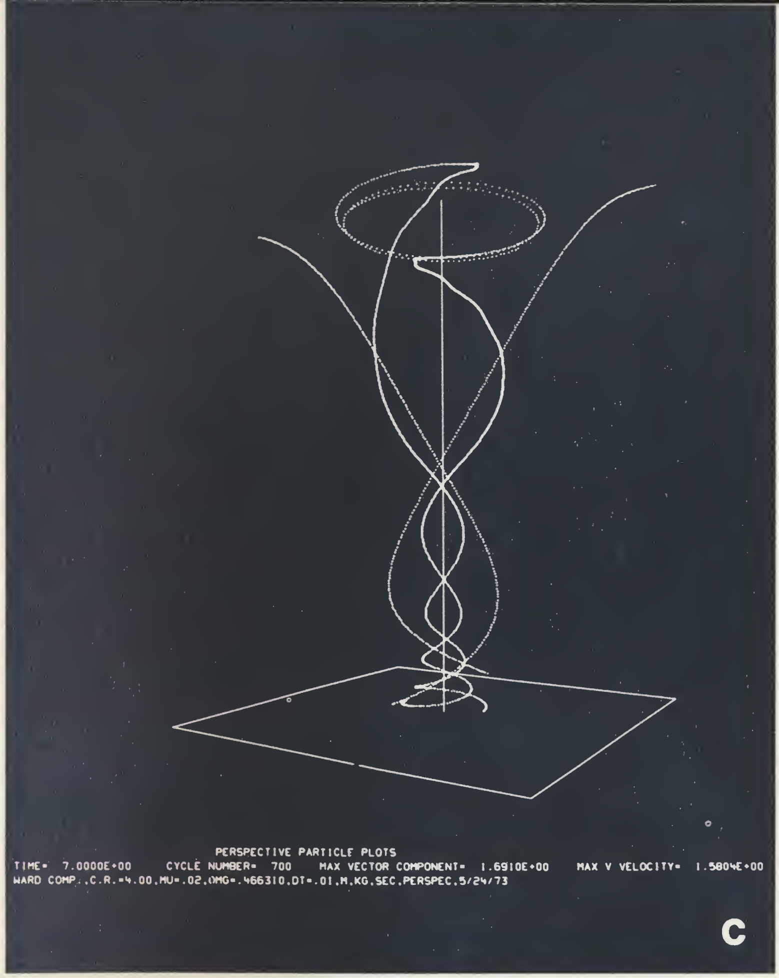
Active in the use of computer graphics since the early 1960's, the Los Alamos Scientific Laboratory is a pioneer in the use of color. LASL developed prototypic hardware to produce computer graphics directly on color film. The first color motion pictures using this now common technique were generated at LASL in 1969.

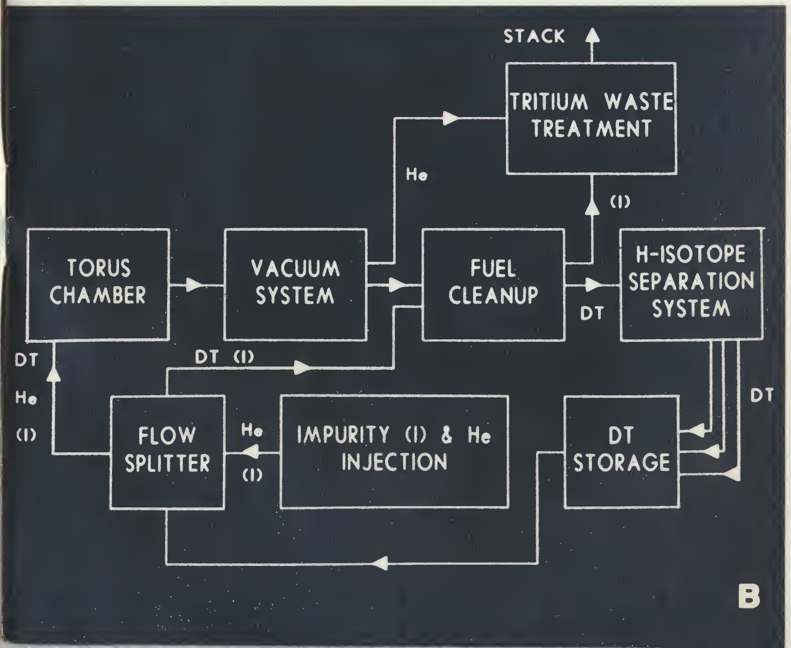
The members of the Laboratory staff apply computer graphics in their daily work. Currently they generate graphics on two to four miles of film per month. Nearly 20 percent of the computer users have interactive graphics terminals in their offices and laboratories. They are continually discovering ingenious and innovative applications of this computer tool.

Many areas of LASL research depend heavily upon the use of computer graphics techniques. These areas include nuclear weapons design, laser fusion studies, fusion reactor design, and reactor safety. For example, using computer simulations, LASL staff study the behavior of laser targets that are being designed for laser fusion facilities and evaluate emergency safety systems in nuclear reactors. Computer graphics also plays a key role in mineral resources evaluation, land-use planning, and world climate studies.

The pictures that follow typify the widespread application of computer graphics at LASL and the diversity of this technology.







A. *An x-y plot used by management to show the annual cycle of personnel growth at LASL.*

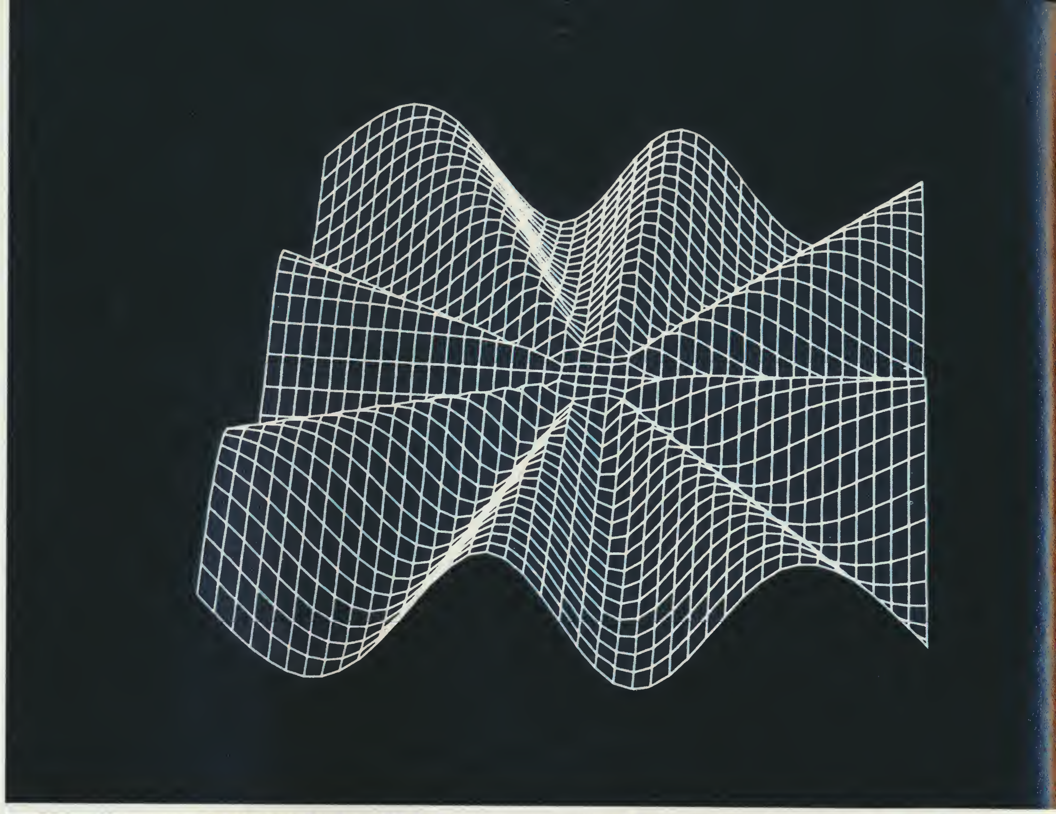
B. *A flow diagram showing a fuel cycle mock-up of a fusion reactor.*

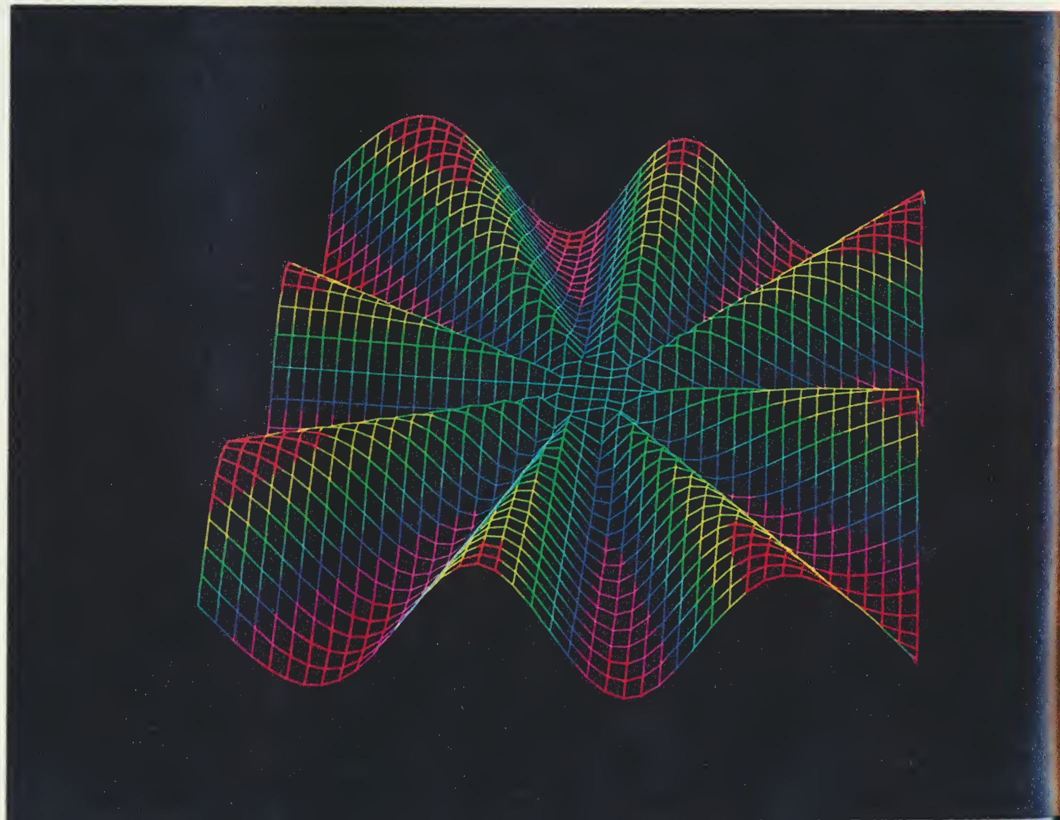
C. *Simulation of the whirling winds of a tornado vortex used in studying an actual tornado in Lubbock, Texas.*

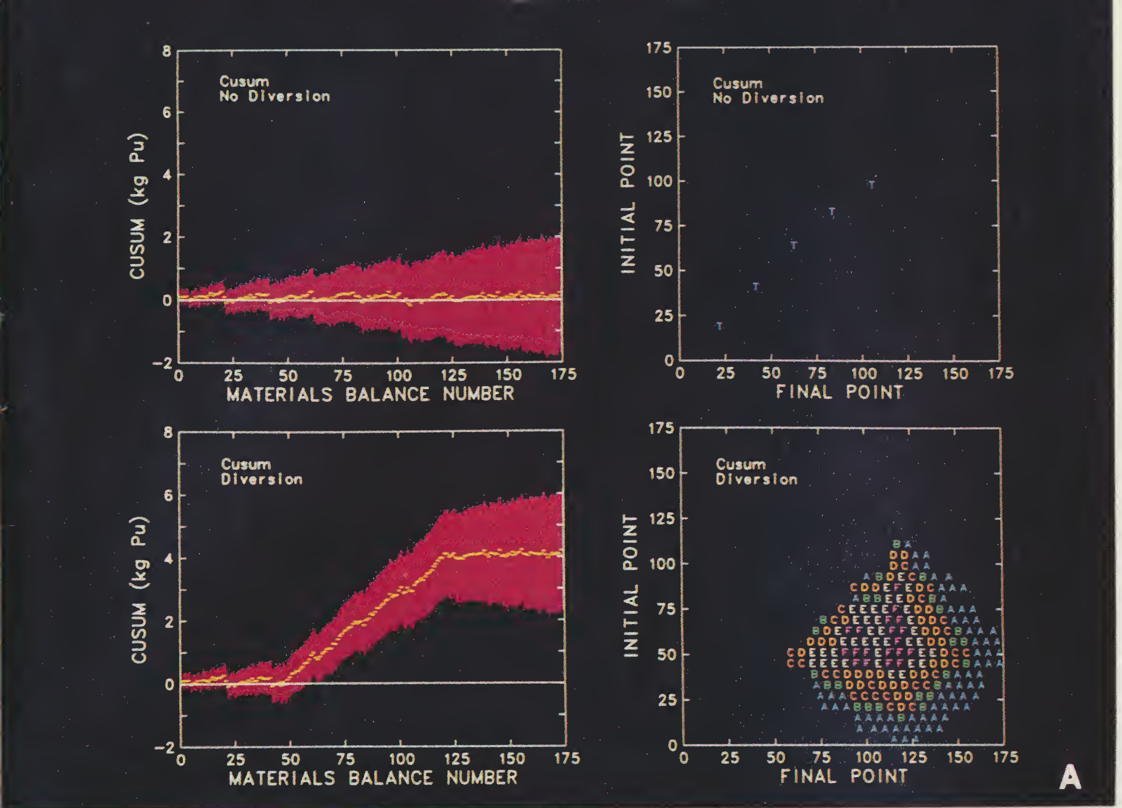
This three-dimensional perspective plot (in black and white and in color) transforms a mathematical equation

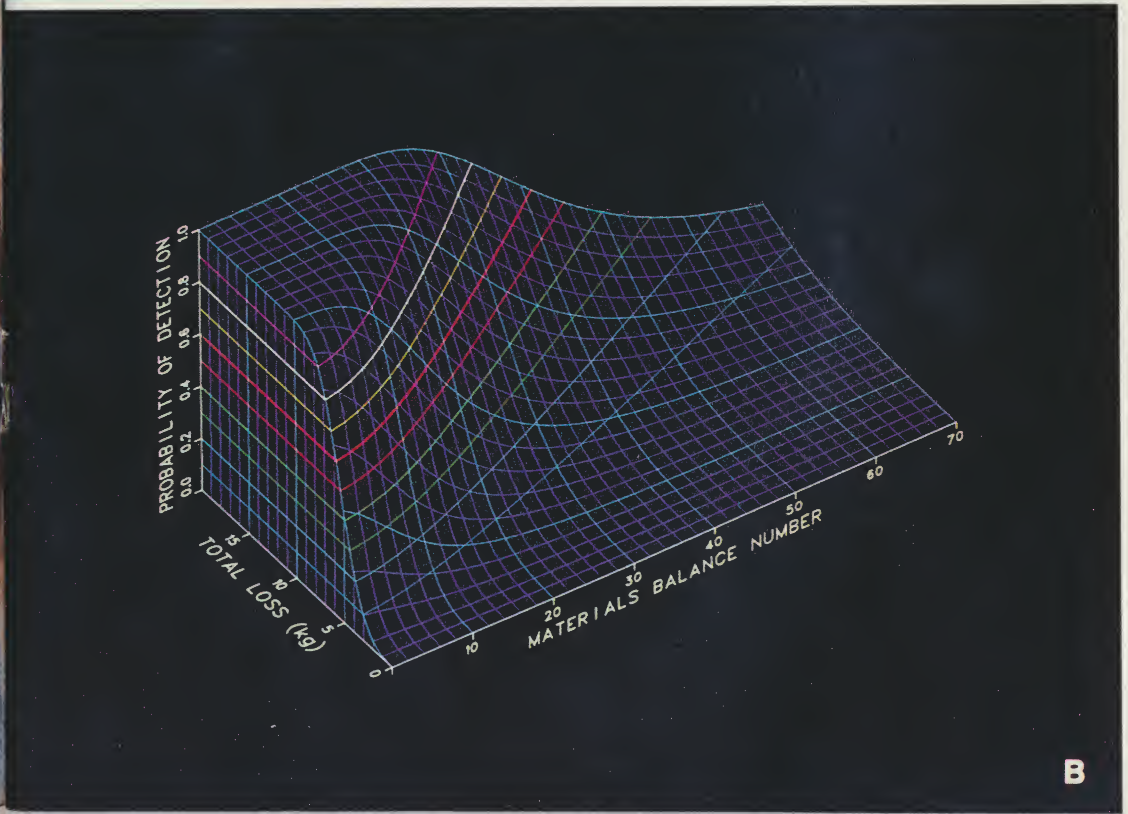
$$z(x,y) = C\sqrt{(x-x_c)^2 + (y-y_c)^2}\ \sin(A)$$

into a visible object. Colors distinguish various amplitudes of the mathematical function.







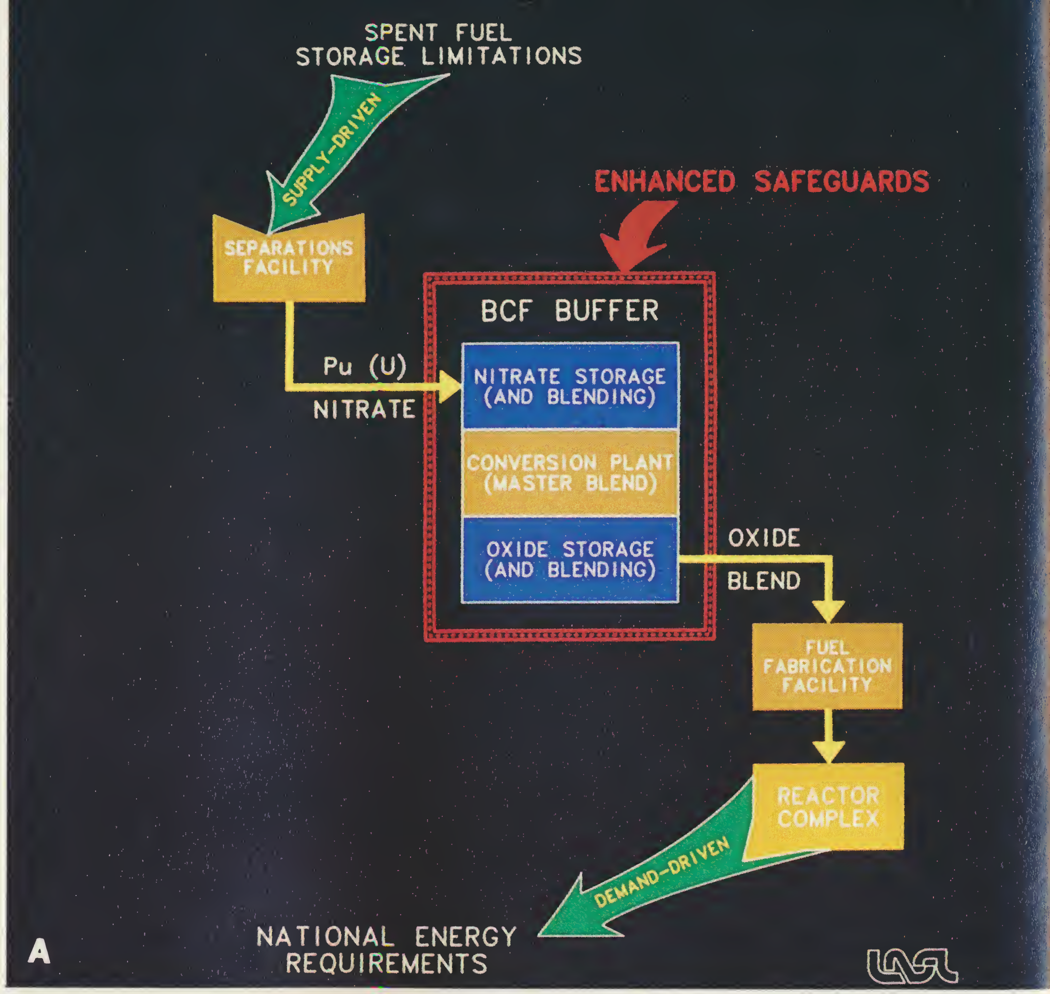


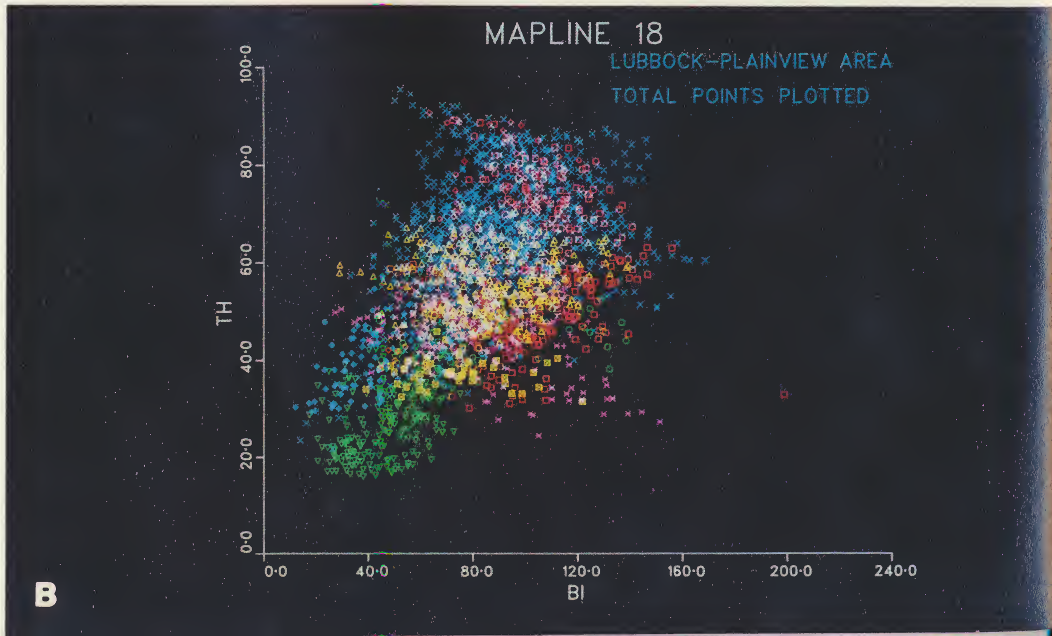
***A.** The current inventory of nuclear fuel materials is carefully monitored with graphic aids. The upper charts indicate the desired situation. The change in the nuclear fuel materials inventory shown in the lower-left chart is restated as an alarm chart in the lower-right corner, where the colored letters illustrate a false-alarm probability.*

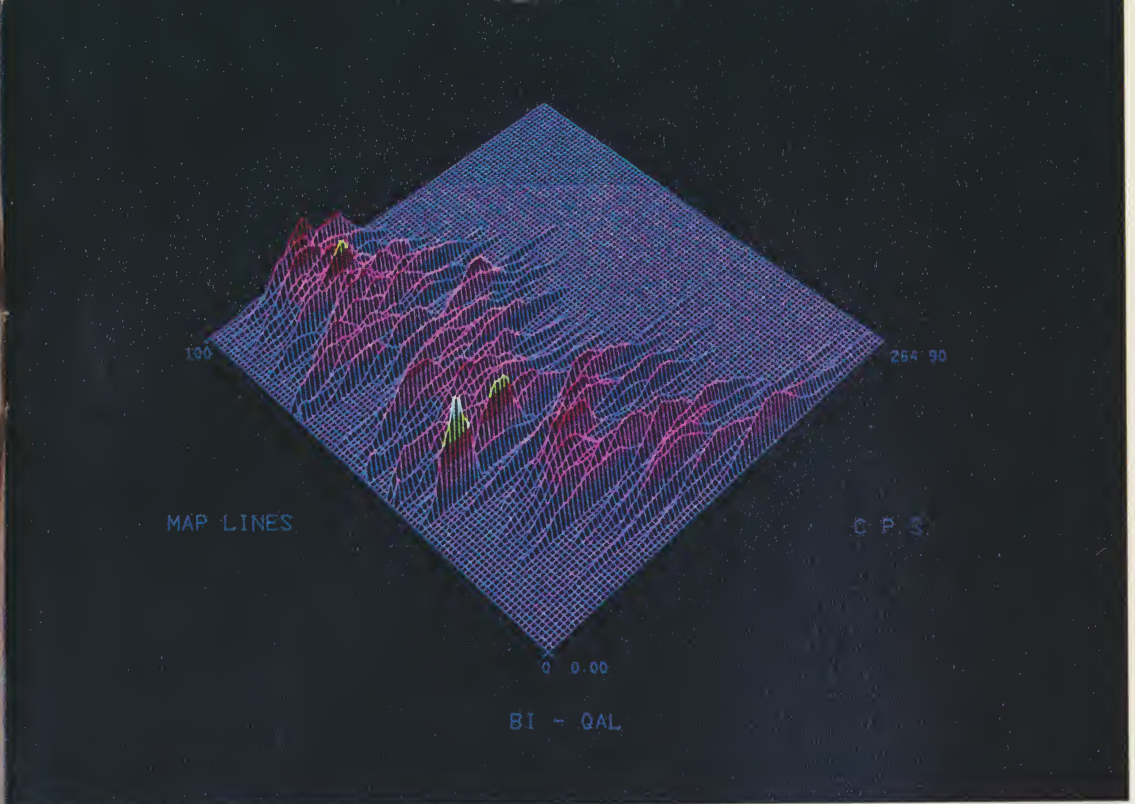
***B.** Three-dimensional surface plot that illustrates the expected performance of an advanced design for a nuclear accounting system. The probability of detecting a change in the nuclear fuel materials inventory is represented by the height of the surface.*

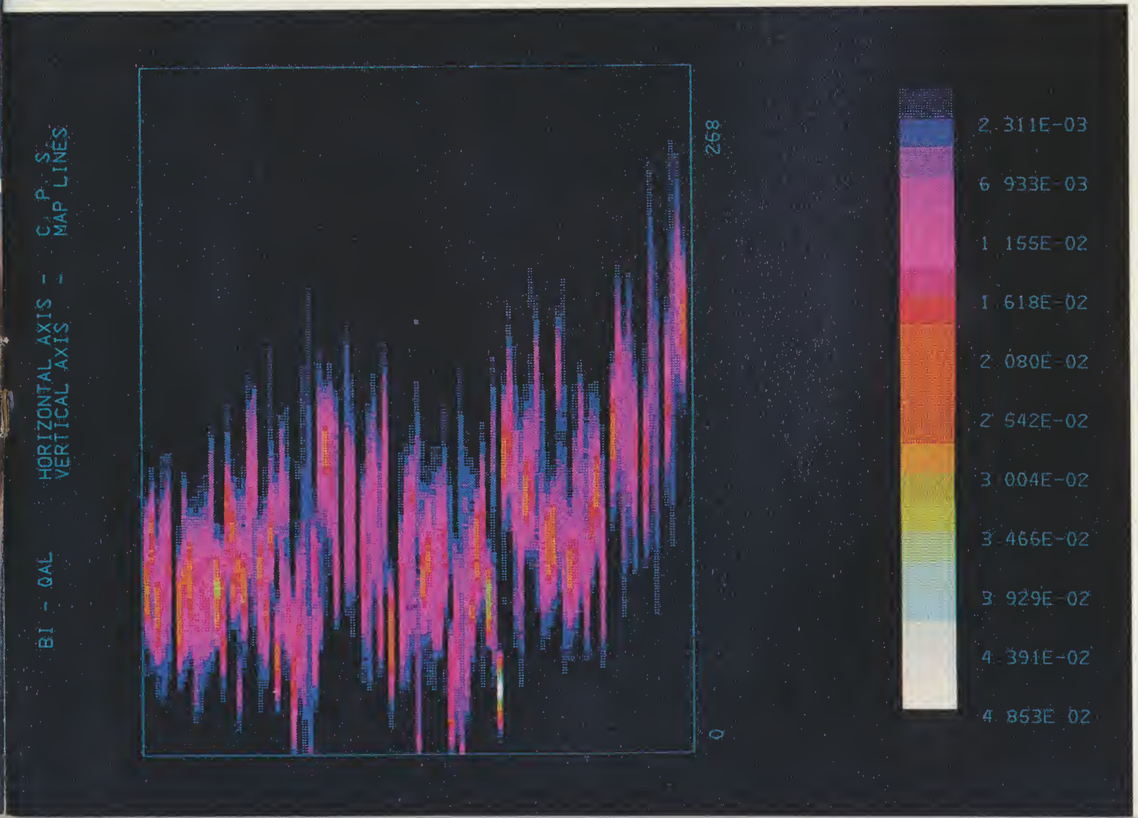
A. *A flow chart that was used in a report on international requirements for nuclear safeguards. It highlights enhanced safeguards in the conversion stage of the nuclear fuel cycle.*

B. *Two-dimensional scatter plot that shows the ratio of bismuth-214 and thalium-208 determined from an aerial radiometric survey over the Lubbock-Plainview quadrangle in Texas. The colors represent different geological formations.*



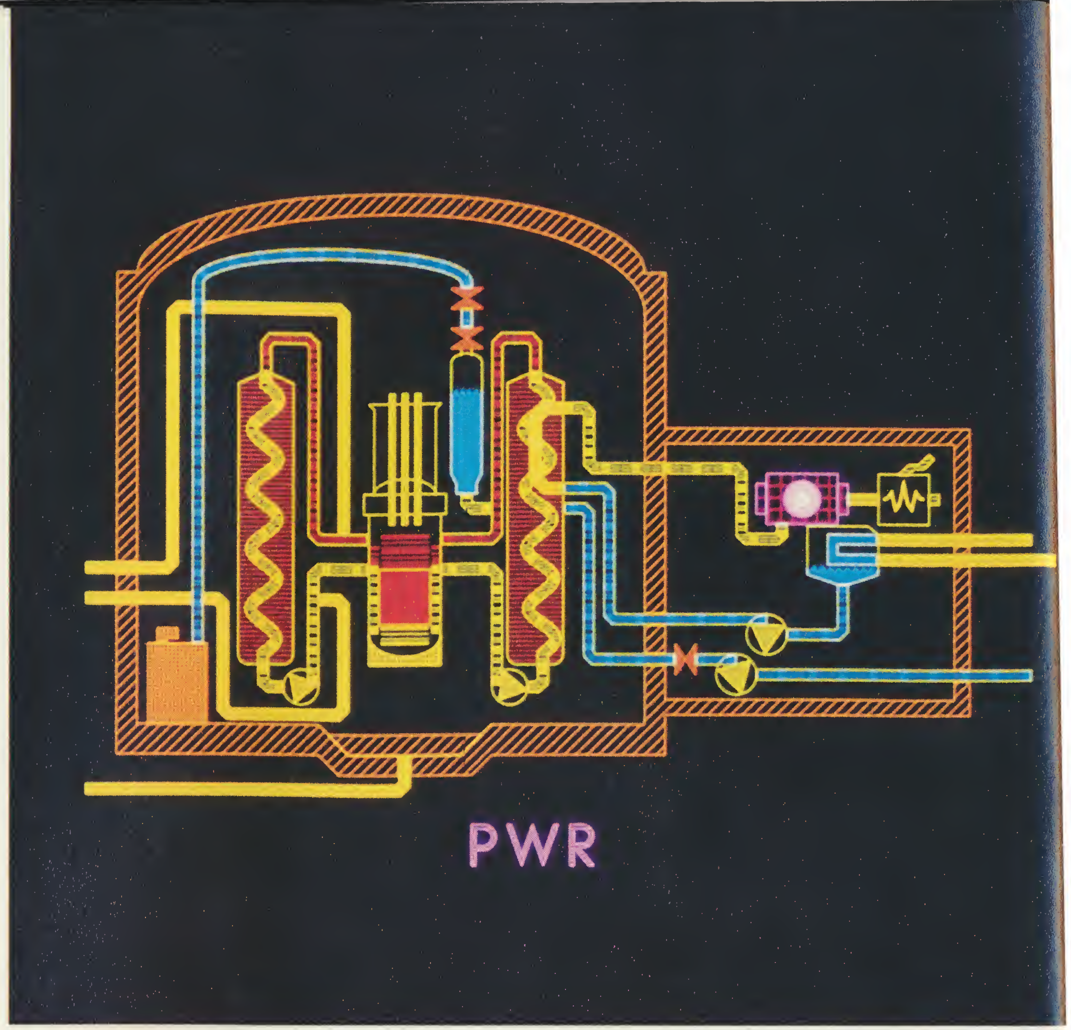


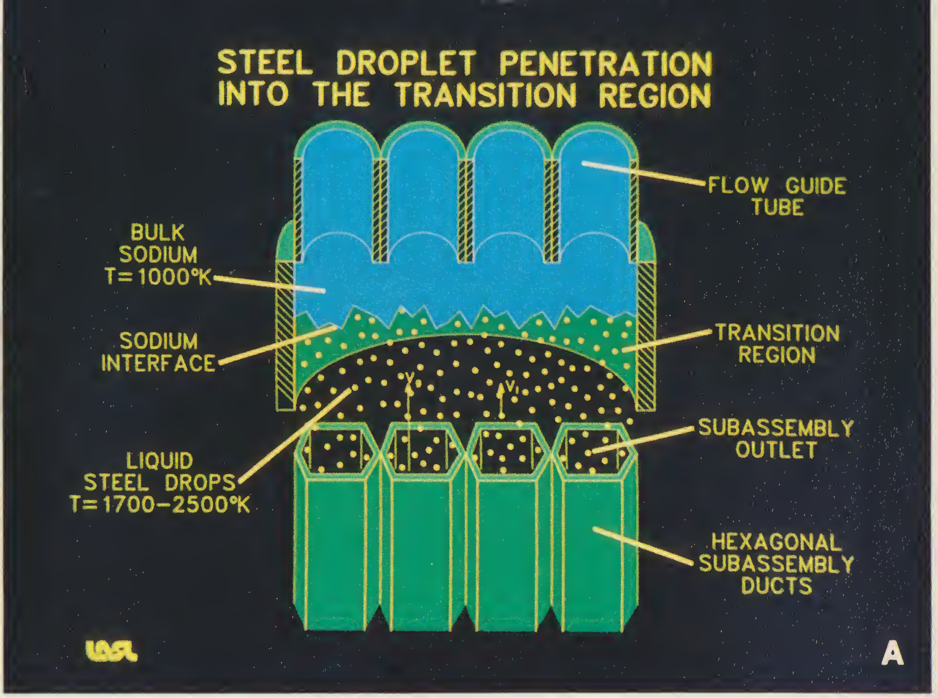


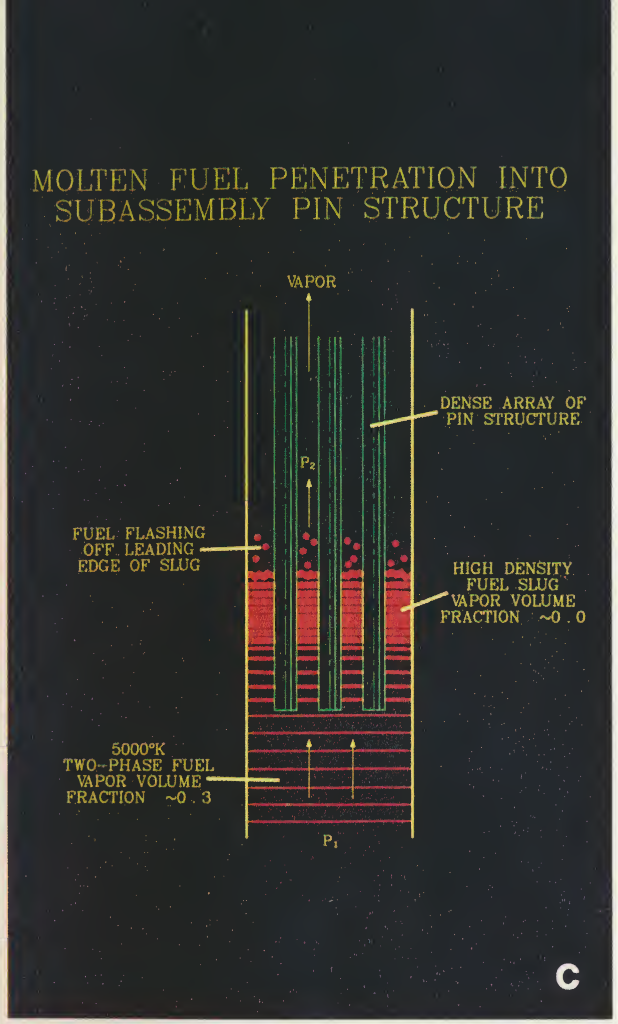


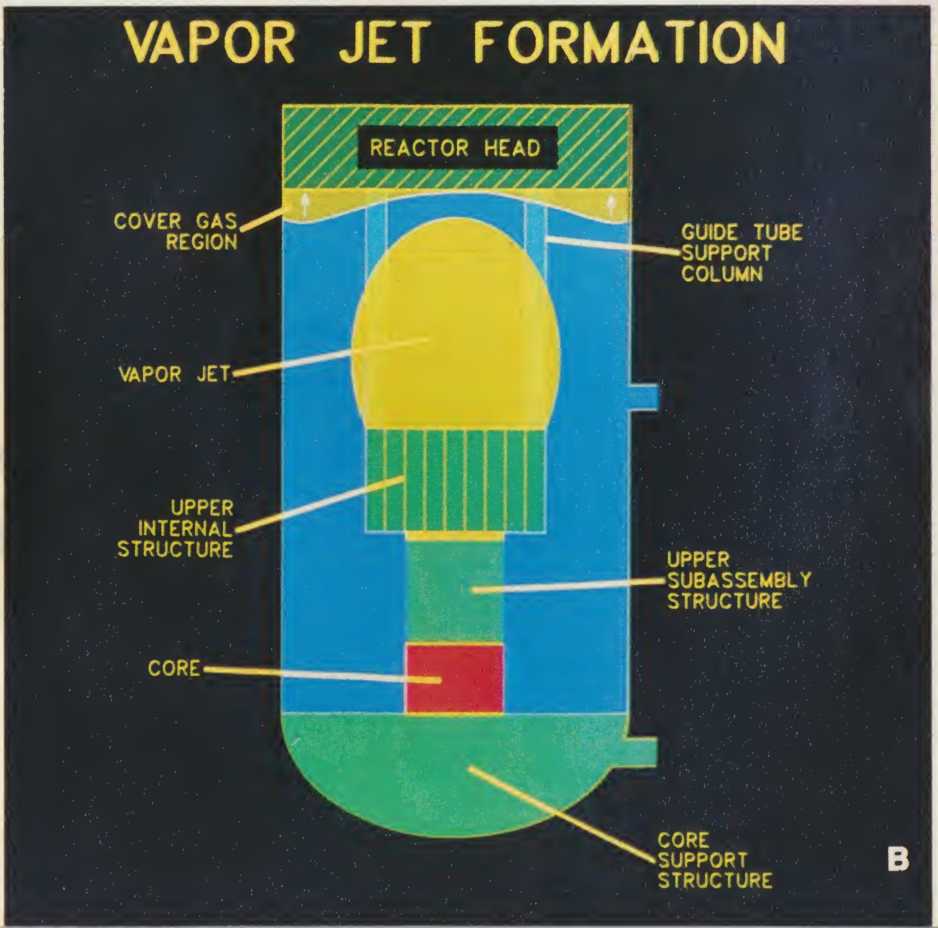
The same data is displayed here in two different ways —a three-dimensional surface (top) flattened into a two-dimensional plot (bottom). Each multicolored streak represents the radiometric data gathered from one flight path of an aerial reconnaissance survey for the National Uranium Resource Evaluation Project. The lighter colors indicate higher bismuth-214 counts per second.

Schematic of a pressurized water reactor used to understand nuclear reactor accidents. The diagram shows the flow of cooler (blue) water into the core section where very hot (red) water surrounds steam generators on each side of the core.









These three illustrations simulate hypothetical physical processes in a liquid metal fast breeder reactor (LMFBR).

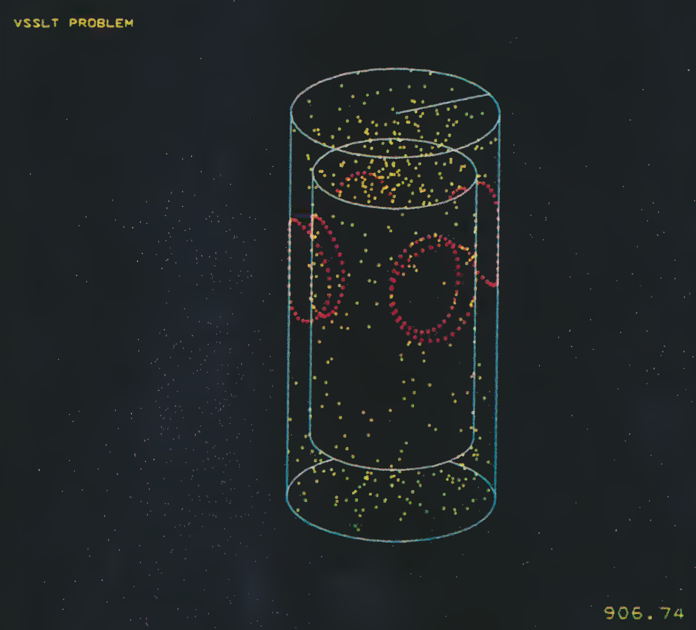
A. *In this computer simulation, the effect of a cutoff of sodium coolant is illustrated. In the transition region, vaporized sodium, vaporized fuel, and liquid steel droplets are pushing against the liquid sodium coolant.*

B. *In this computer simulation, stoppage in the flow of the sodium coolant results in the formation of a gaseous bubble composed of fuel, sodium, and steel vapors. The picture illustrates the expansion of this bubble as it pushes against the reactor head.*

C. *In this computer simulation, a cross section of a small part of the reactor core shows melted fuel rods, which create plugs between the rods. The intensity of the red tone indicates increased density of melted fuel.*

A. *Three-dimensional picture from a computer-generated movie displaying the flow of water (yellow) and steam (magenta) in the pressure vessel of a nuclear reactor during a simulated loss of coolant.*

B. *A mesh plot of a reactor core. Colors represent different core materials. This plot is used to understand the physical location of each core material.*



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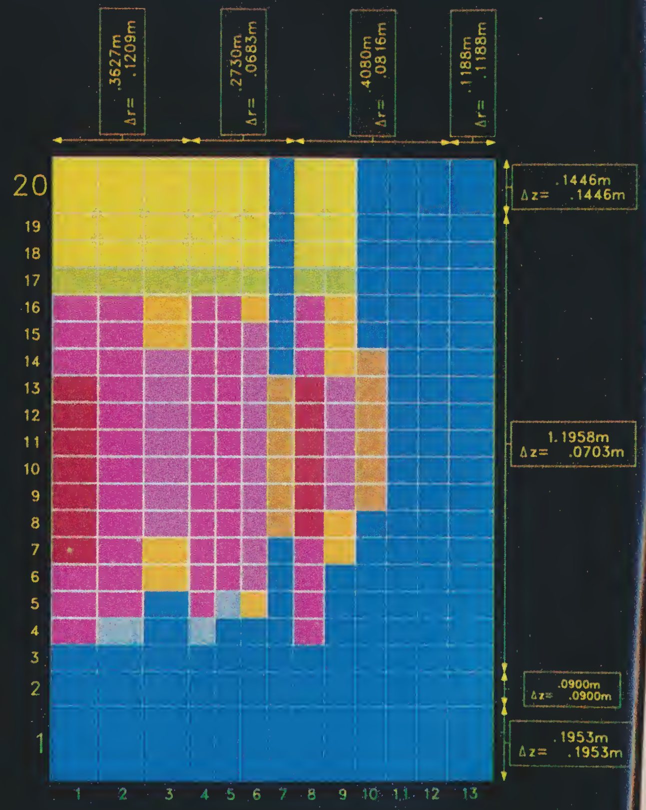

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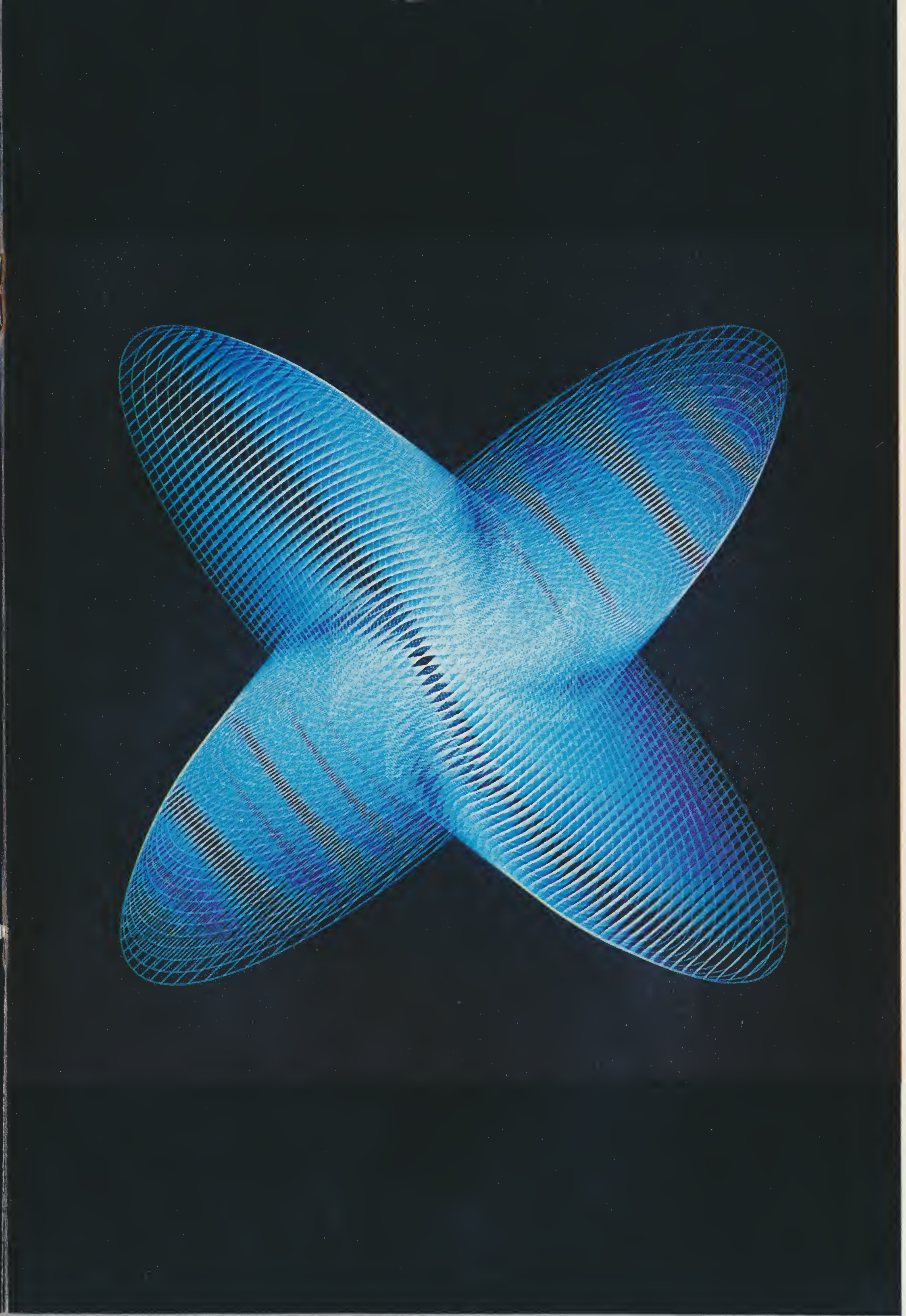
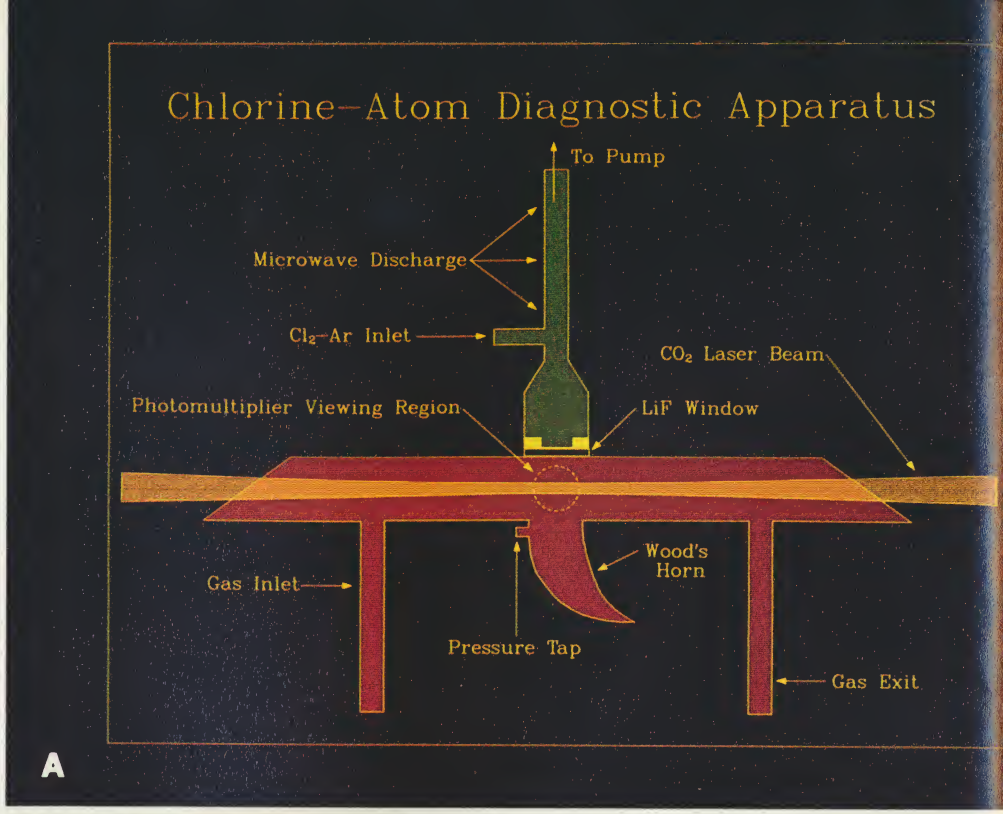
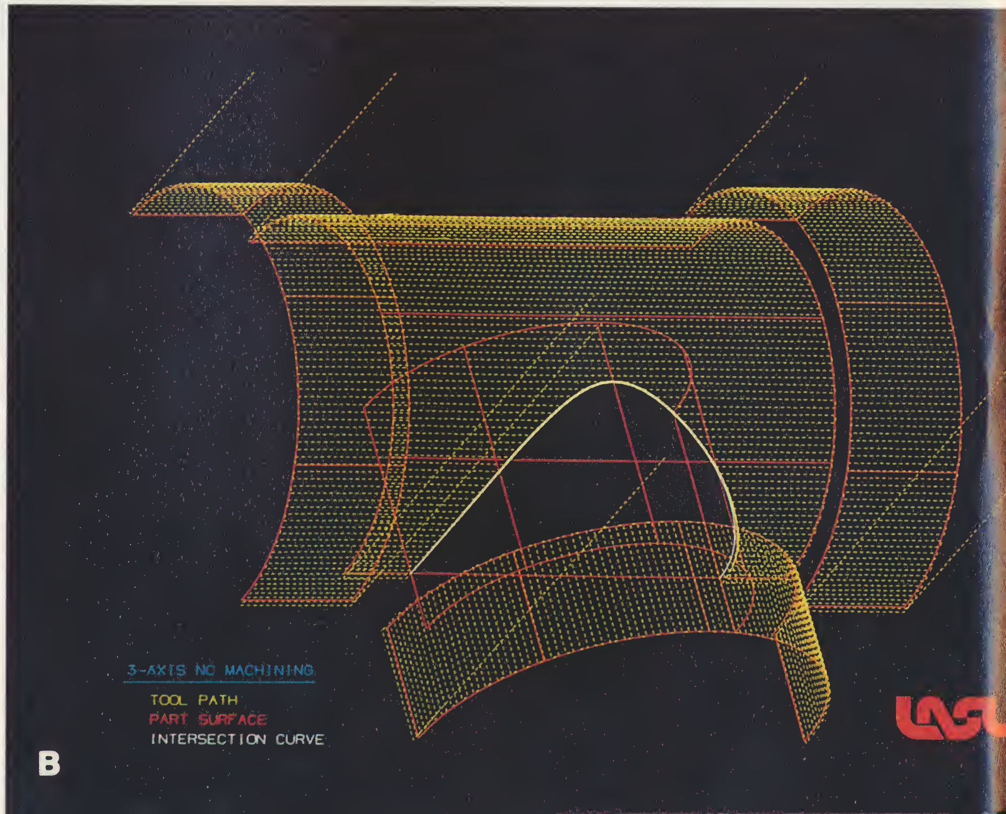


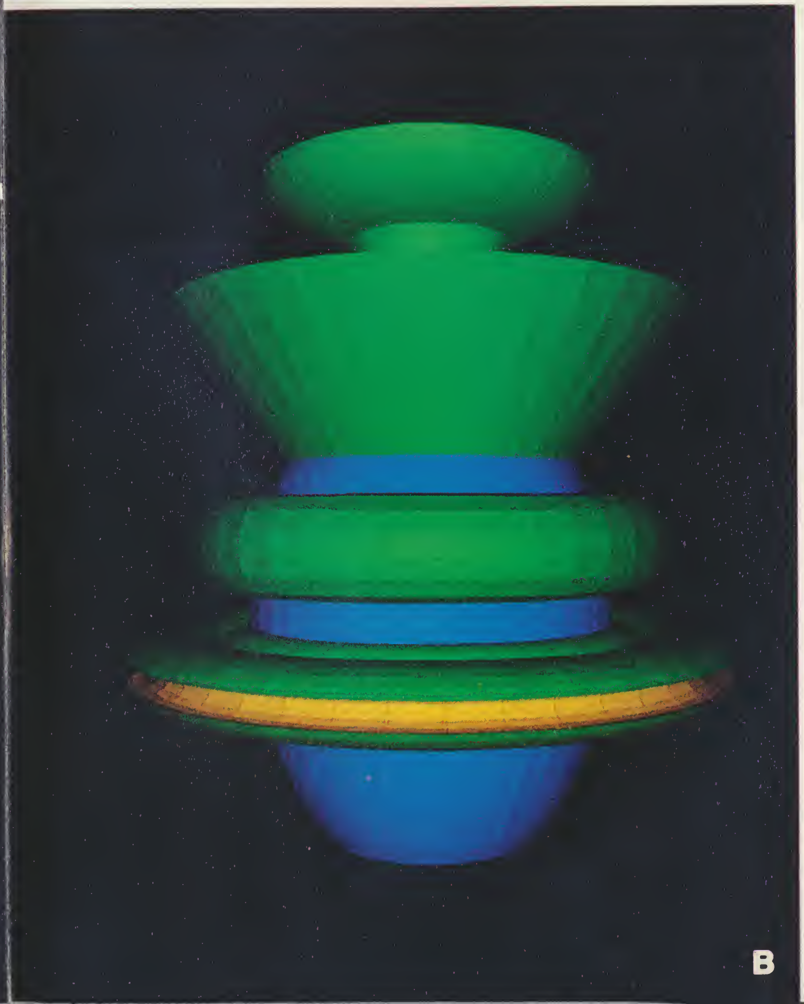
An example of computer art produced by enlarging and rotating a tiny "flower" many times. Cross-hatching gives a shaded effect.

A. *An experimental apparatus used in the laser isotope separation program to study the production of chlorine atoms in a chemical reaction induced by a carbon dioxide laser beam.*

B. *Computer-aided manufacturing—the simulation of a machine tool cutter path (yellow) as it traverses a cylindrically defined surface (red). After verification, a precision part will be machined using a numerically controlled machine tool.*





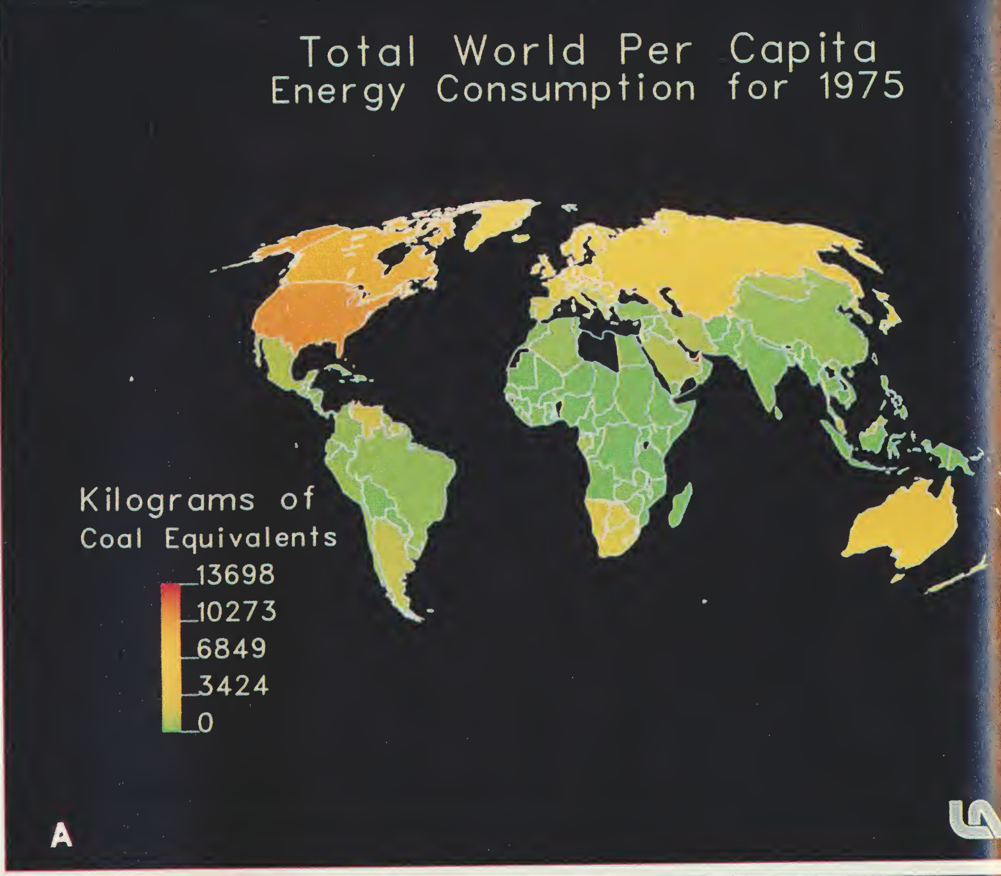


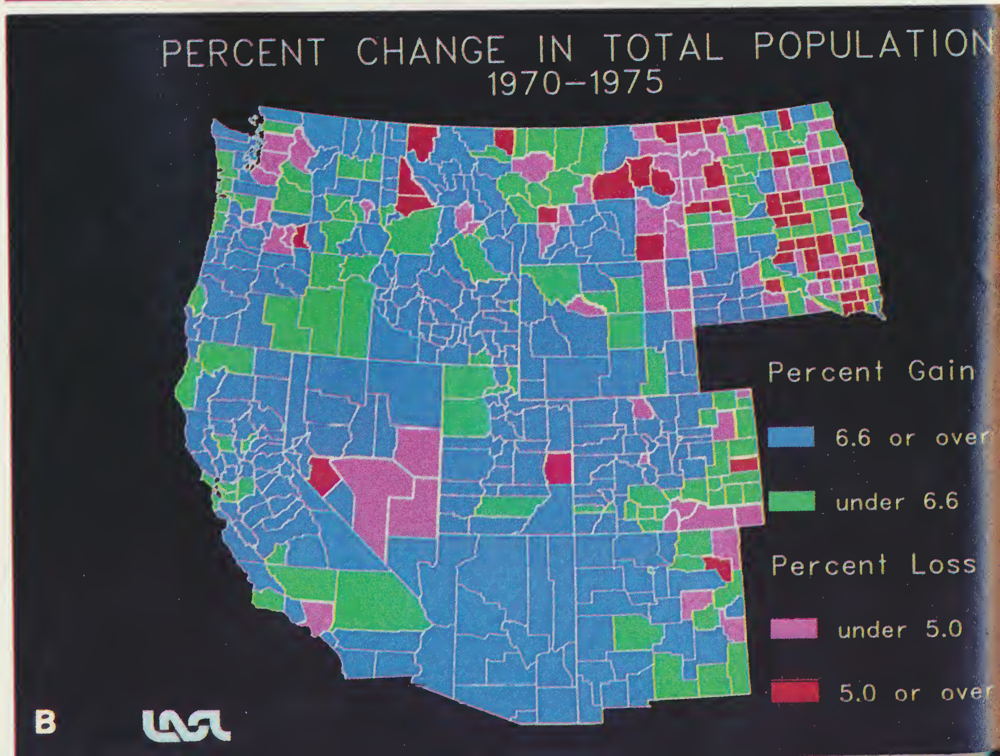
A. *A three-dimensional model of a graphite block segment that is used to support the core of a high-temperature, gas-cooled reactor. Color is necessary to communicate temperature distribution in the graphite block during a cool-down period. (Red is the hottest; blue is the coolest.)*

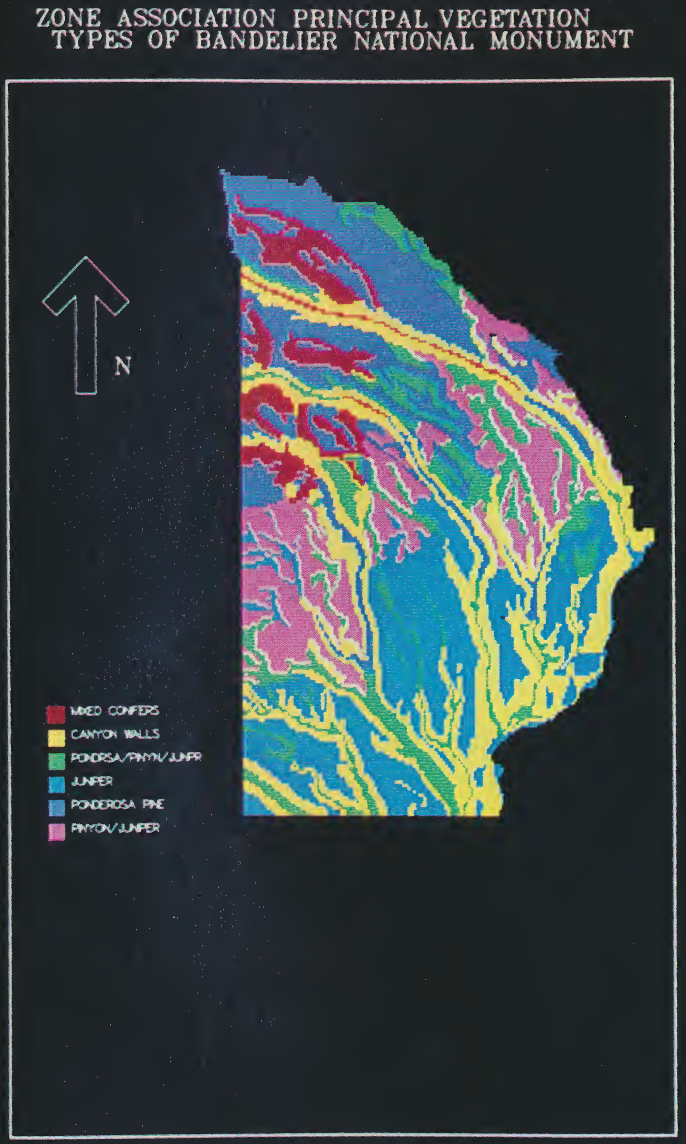
B. *A simulated test surface used to study particle transport computer programs. These programs track random neutrons and photons through three-dimensional material cells that can cause the splitting of atomic particles.*

A. *A world map showing per capita energy consumption by country. Color aids the eye in quickly identifying patterns of energy consumption.*

B. *This color-coded map illustrates population shifts by county.*







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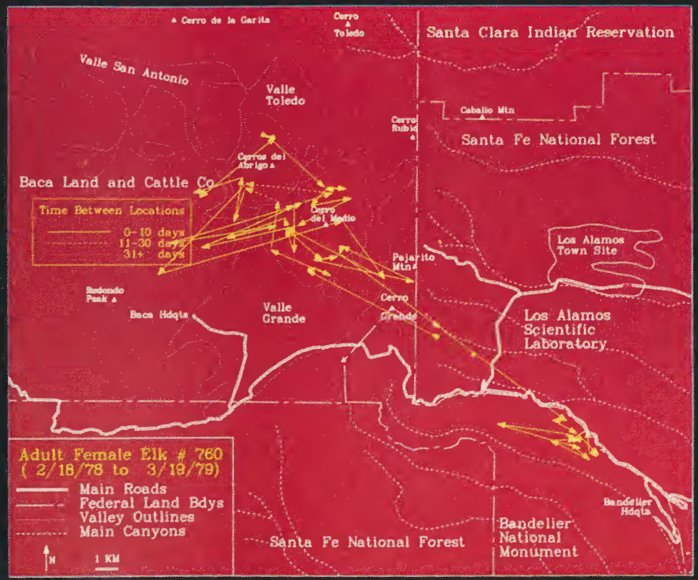


B

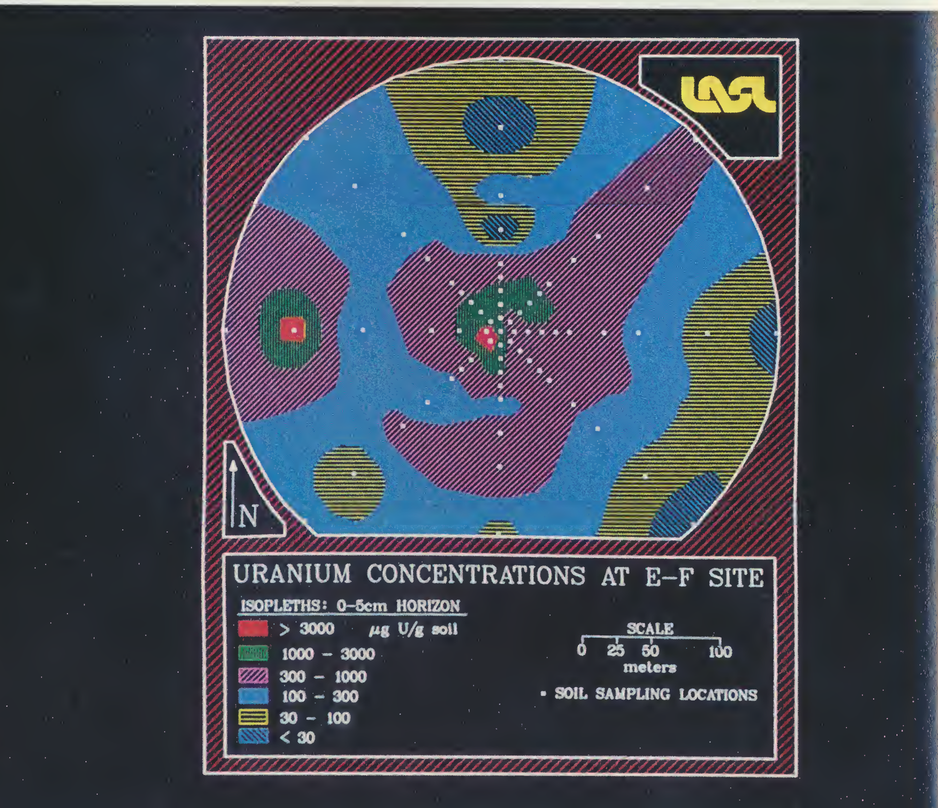
A. *A color-coded map of the principal types of vegetation in Bandelier National Monument, New Mexico, helps the Park Service in land-use planning.*

B. *Elk movement in the eastern Jemez Mountains of New Mexico. The yellow lines trace the movements of a radio-collared elk tracked by Los Alamos National Environmental Research Park personnel.*

A. *The surface temperatures of the northern hemisphere, looking down at the North Pole. This contour plot was produced by a numerical model of the Earth's climate. This model is being developed by LASL and the National Center for Atmospheric Research.*

B. *The migration of uranium at an old weapons test site after a number of years.*

A



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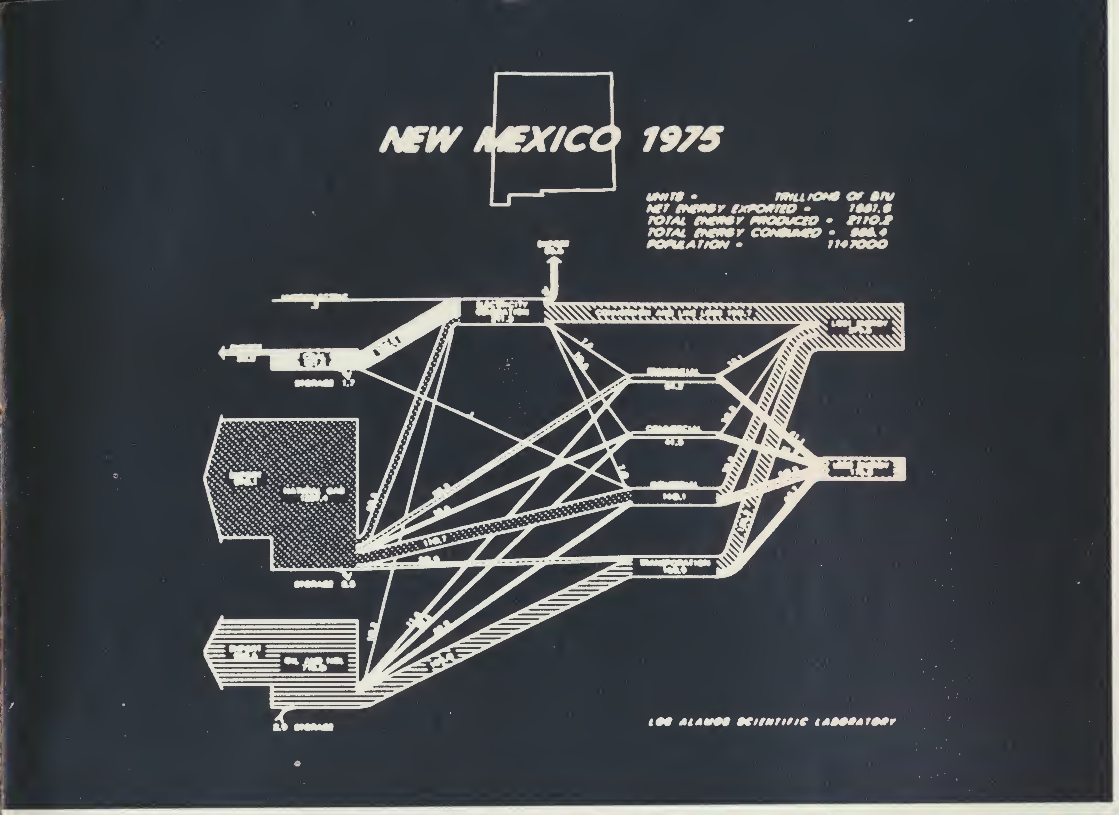
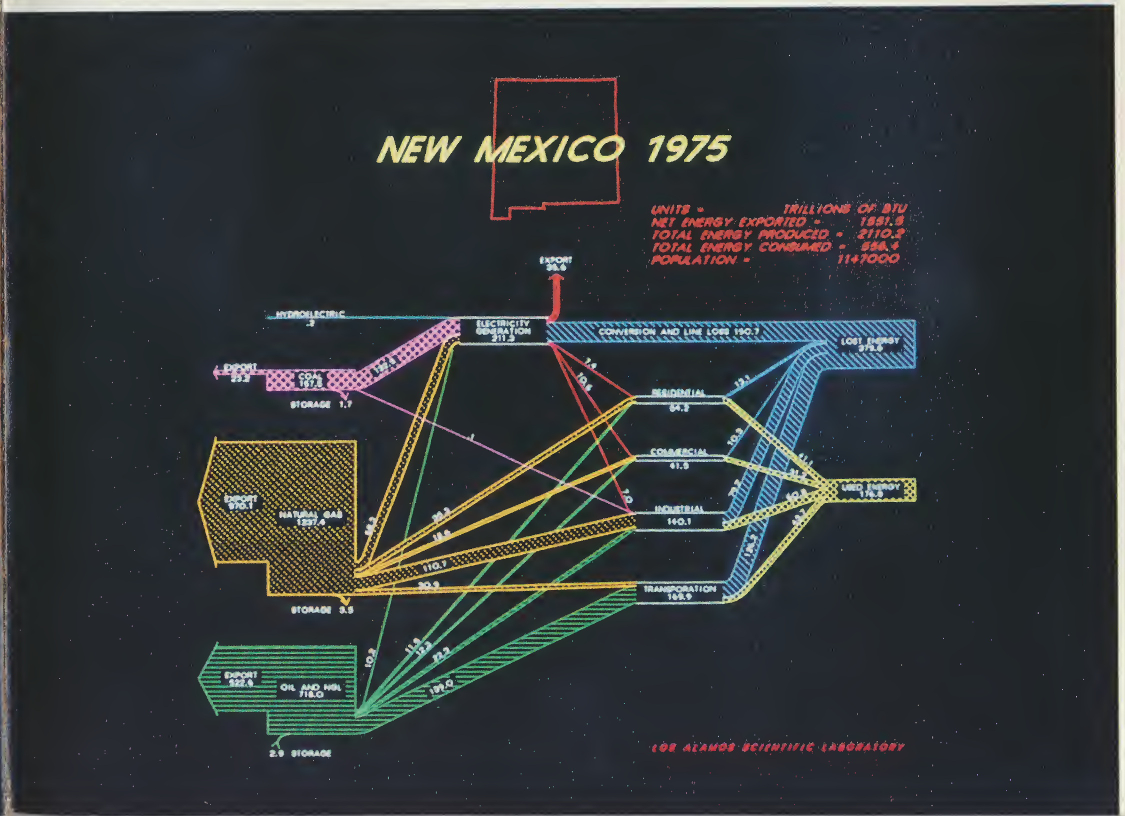
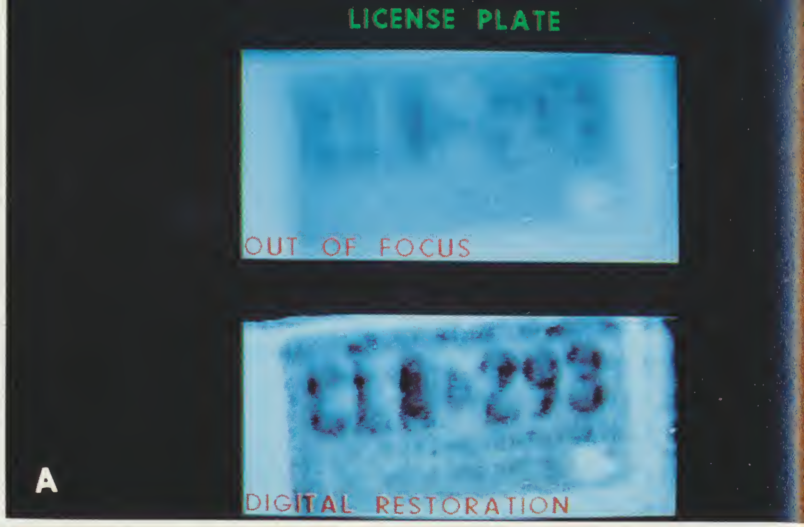


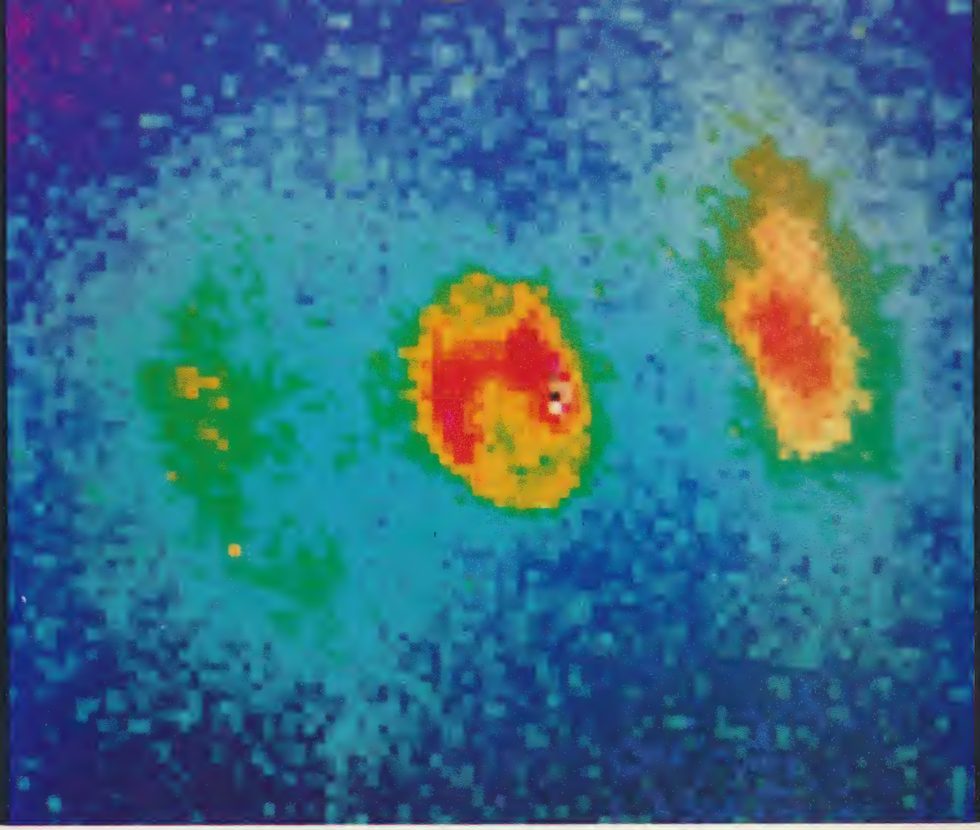


An energy flow diagram is a convenient aid in the study of energy statistics and problems. This diagram (in black and white and in color) illustrates New Mexico's production of various kinds of energy, consumption of this energy within specific sectors of society, and total energy used, lost, and exported. Notice how color highlights the relationships among these components.

A. *A blurred license plate becomes legible through digital image processing, an application of raster graphics. The top picture is the digitized image of a blurred photograph; the lower picture is the resulting image after it has been improved through image restoration.*

B.&**C.** *Digitized photograph of a landscape (**upper**) is integrated with simulated atmospheric pollution to show the visual effects of air pollution (bottom). These images are examples of the realistic representation possible with raster graphics.*





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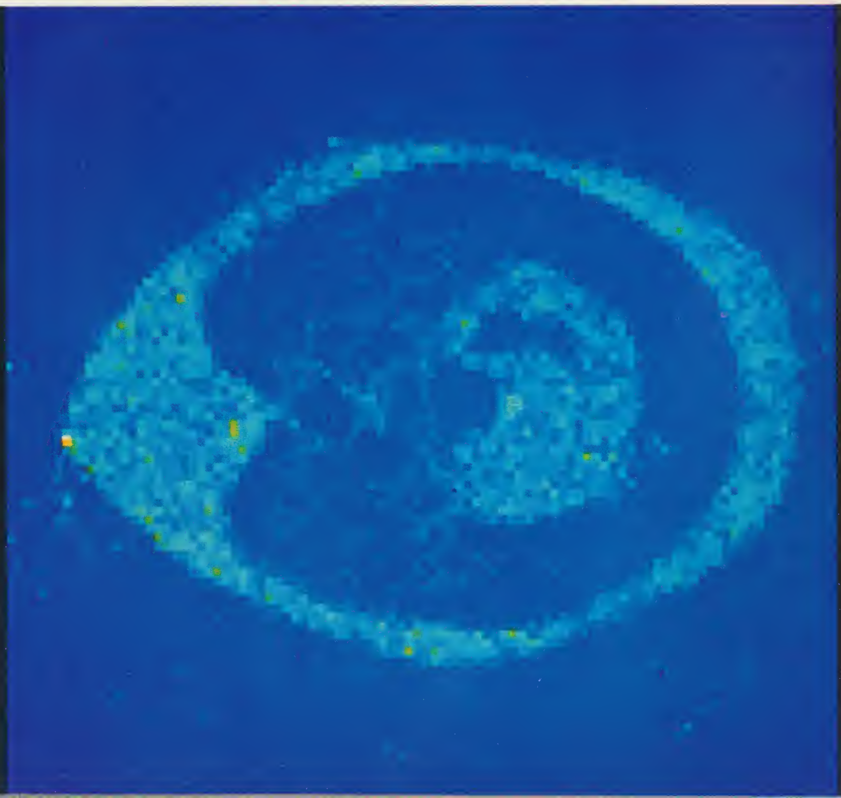

B

A. *Raster graphics display of the x rays emitted when a gas-filled microballoon has been compressed by an intense laser-beam pulse. The center (red portion) has been successfully compressed to a high temperature and emits intense x rays. The halo surrounding the central portion indicates the location of the original shell before compression.*

B. *Cross-sectional image of the interior of a dog's chest produced by computer tomography. The computer processes several chest x-ray photographs taken at different angles to produce one cross-sectional image. In this raster graphics display, the outer ring is the rib cage with the backbone at the left; the two-chambered heart is visible in the center.*

Computer Graphics Motion Pictures

Motion pictures are an important aid to scientific research. Some processes vary with time; some phenomena can be observed only by projecting scientific plots in rapid sequence onto a screen; some objects must be rotated to study all sides. The LASL films listed below focus on computer graphics techniques and are available on loan.

Animate
August 1979, Film Y-356
Color, optical sound, showing time—4 minutes, unclassified, 16 mm.

This film demonstrates several cinemagraphic effects that can be easily produced with the computer graphics programs MAPPER and ANIMATE. Some of the cinemagraphic effects are animation titles, fades, dissolves, and wipes.

Galaxy M-104
July 1979, Film Y-336
Color, optical sound, showing time—7 minutes, unclassified, 16 mm.

This film discusses the nature of galaxies, then focuses on the so-called Sombrero galaxy, M-104, to discuss recent research at LASL in which computers are used to enhance the clarity of light data by removing interference caused by Earth's atmosphere. Computer graphics in three dimensions, color, and rotational perspective are displayed.

Applied Computer Fluid Dynamics
May 1979, Film Y-331
Color, optical sound, showing time—24 minutes, unclassified, 16 mm.

This film presents a variety of complex hydrodynamics problems that are being examined at LASL through the use of computer techniques. Areas studied include tornado dynamics, tidal waves, reactor-core behavior, wind on motor vehicles, waves on ships, blood flow against vessel constrictions, internal combustion engine dynamics, and atomic nuclei collision dynamics. The film introduces each area of study through interesting live footage that sets the experimental stage.

Time Evolution of Coherent States for General Potentials
December 1978, Film Y-333
Color, optical sound, showing time—13 minutes, unclassified, 16 mm.

This film discusses a procedure for finding coherent states for quantum mechanical particles in various potentials. (Coherent states are states that follow, as well as possible, the motion of a classical particle in the same potential.) Computer-generated graphics show the time evolution of these states.

Infinity's Child
November 1978, Film Y-275
Color, optical sound, showing time—22 minutes, unclassified, 16 mm.

This film introduces computer graphics through a short history of the rise of human intelligence. The concept of a bicameral brain is explained, and the design of the computer is described as an extension of the brain, "a lens for the mind's eye." Computer-generated graphics are displayed, illustrating a variety of calculations that have originated from energy and environmental projects under way at LASL.

Mapper
October 1978, Film Y-330
Color, optical sound, showing time—8 minutes, unclassified, 16 mm.

This computer-generated motion picture describes the ease of using the movie capability in MAPPER, an easy-to-learn computer program designed to make quality visual aids for presentations and reports. The MAPPER program is in use at LASL.

Modeling a Gas-Water Reservoir
February 1978, Film Y-321
Color, optical sound, showing time—6 minutes, unclassified, 16 mm.

Through computer graphics, the mathematical modeling of various production rates in a gas-water reservoir is presented. This is a good example of visuals used to present mathematical modeling of engineering concepts.

Interactive Graphics at LASL
November 1977, Film Y-277
Color, optical sound, showing time—6.5 minutes, unclassified, 16 mm.

This film describes the application of the interactive graphics terminal to the rapid solution of complex hydrodynamics problems at LASL.

Thermal Analysis in Mold Design
June 1977, Film Y-306
Color, optical sound, showing time—4 minutes, unclassified, 16 mm.

All of the visuals in this short film were produced by computer. These graphics represent the mathematical modeling of experiments in mold design. The developmental history of a specific mold is used to demonstrate the process.

Matrices and Their Singular Values
June 1976, Film Y-285
Color, optical sound, showing time—6.5 minutes, unclassified, 16 mm.

Using computer graphics, the importance of matrices in the solution of certain types of problems is explained. The actual solution procedure is discussed and demonstrated.

Computer Graphics Report
March 1976, Film Y-280
Color, optical sound, showing time—10 minutes, unclassified, 16 mm.

This film presents a short history of computer graphics development at LASL. Examples are given of early two-dimensional black-and-white

graphics in motion. Advances in technical achievement are documented through the development of color and three-dimensional graphics with rotational perspective. Examples used to illustrate the technology are taken from various environmental and other research projects at LASL.

Computer Movies Aid to Energy Research
November 1975, Film Y-281
Color, optical sound, showing time—10 minutes, unclassified, 16 mm.

This film shows four areas of energy research where computer-generated motion pictures are used in design considerations. The four areas are high-powered laser pulses, solar heating and cooling, laser fusion power plants, and pollution studies of power plant stacks.

Solar Architecture
September 1975, Film Y-271
Color, optical sound, showing time—4.5 minutes, unclassified, 16 mm.

This film demonstrates the use of three-dimensional computer graphics for architectural planning to achieve the best solar-collector orientation of the National Security and Resources Study Center at LASL.

Physical Simulations with Computer Color Generations
June 1975, Film Y-269
Color, optical sound, showing time—6 minutes, unclassified, 16 mm.

This film demonstrates the computer display of the same problem in three different ways: mesh plot, contour plot, and three-dimensional isometric plot.

Computer Color Generations
April 1973, Film Y-200
Color, optical sound, showing time—23 minutes, unclassified, 16 mm.

This documentary motion picture deals with a technique developed at LASL, whereby computers can produce color film output at no increase in cost over normal black-and-white film. The advantages of color over black and white are discussed using computer movie runs as examples. Areas of Laboratory research illustrated include lasers, engineering, controlled thermonuclear research, and various three-dimensional problems.

LASL-produced films are available on loan at no cost or may be purchased by writing or phoning:
Los Alamos Scientific Laboratory
Film Library, Mail Stop 364
P. O. Box 1663
Los Alamos, NM 87545
Tel: (505)667-4446
Please order by title and production number ("Y" number).

For technical information regarding computer graphics techniques, contact:
Los Alamos Scientific Laboratory
Group C-6, Mail Stop 272
P. O. Box 1663
Los Alamos, NM 87545

Produced by: the C-2 Documentation Group and the Public Relations Department

For more information contact:
Computer Science and Services Division
Group C-2, Mail Stop 253
P. O. Box 1663
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Lucy Carruthers, Q-13
Kathleen DeGasperi, H-1
Thomas Dixon, WX-3
Raymond Elliott, C-6
James Ferguson, X-6
Carol Ann Greiner, S-2
Patrick Hodson, Q-7
Myrle Johnson, S-1
Robert Jurgens, C-6
E. A. Kern, Q-4
Russell Kidman, T-2
John Langford, WX-3
John Lyman, AP-4
Robert Malone, T-1
David Martinez, Q-4
Felix Miera, LS-6
Gerald Minerbo, X-9
Glenn Morris, S-2
Margaret Patterson, AO-DO
Melvin Prueitt, X-4
Virginia Romero, C-2
Margaret Scott, Q-4
John Sibert, S-1
Leland Stein, T-3
Gayle Thomas, S-1
Joel Trussell, M-5
Mona Wecksung, S-3
Gary White, LS-6
David Whiteman, S-1
Michael Williams, John Muir Institute
Keith Zeigler, Retired, LASL

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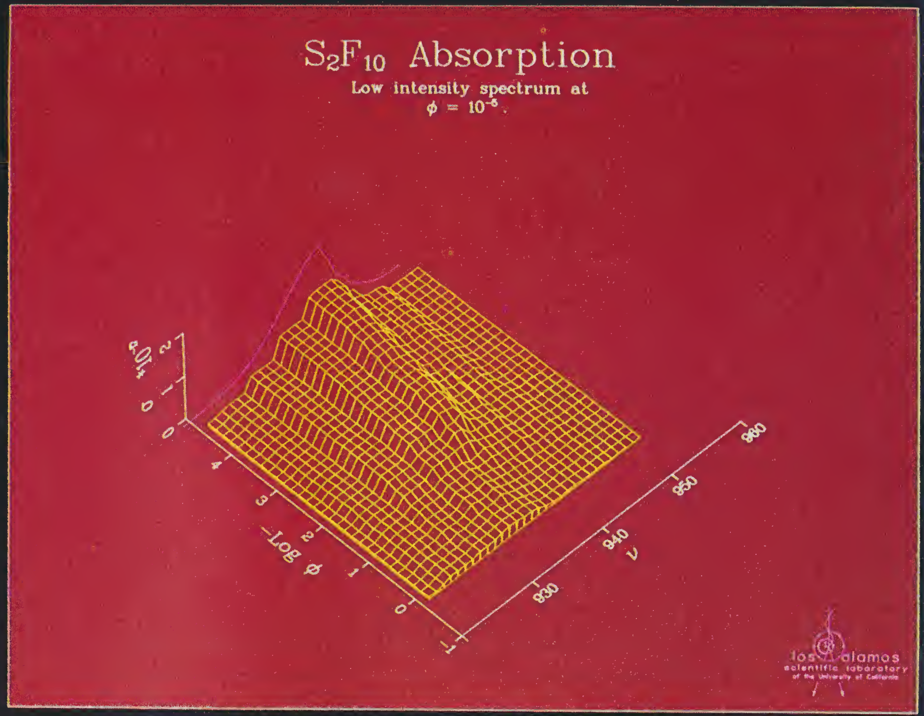
University of California

LOS ALAMOS SCIENTIFIC LABORATORY

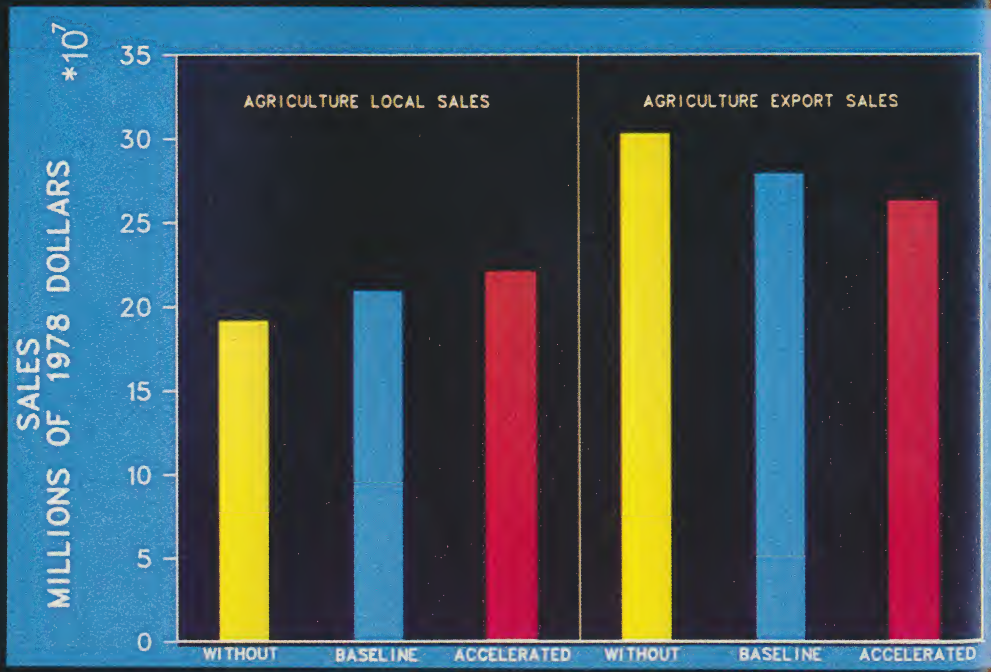
LASL 80-25

A. *The absorption of laser energy by sulfur fluoride gas molecules is represented in this three-dimensional plot. This information is important in laser isotope separation for the enrichment of uranium.*

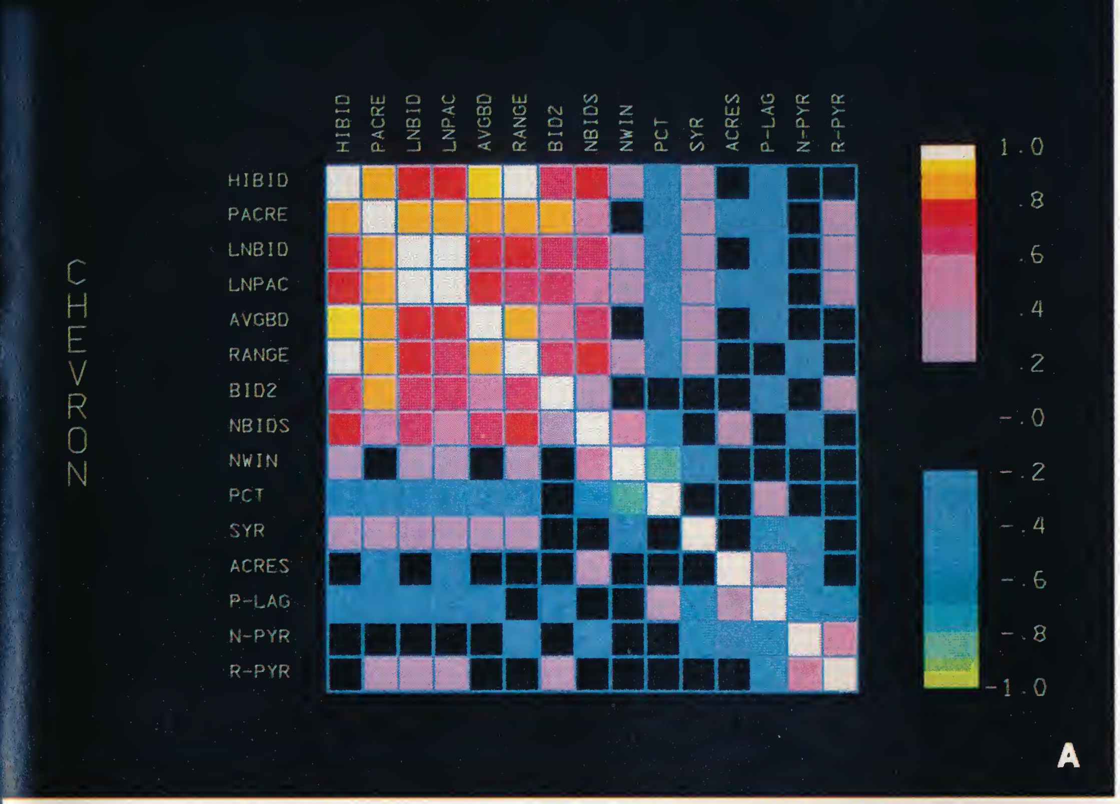
B. *This bar chart compares the effect on agricultural sales of various levels of synthetic fuels production in the year 2000 in the Upper Colorado River Basin.*

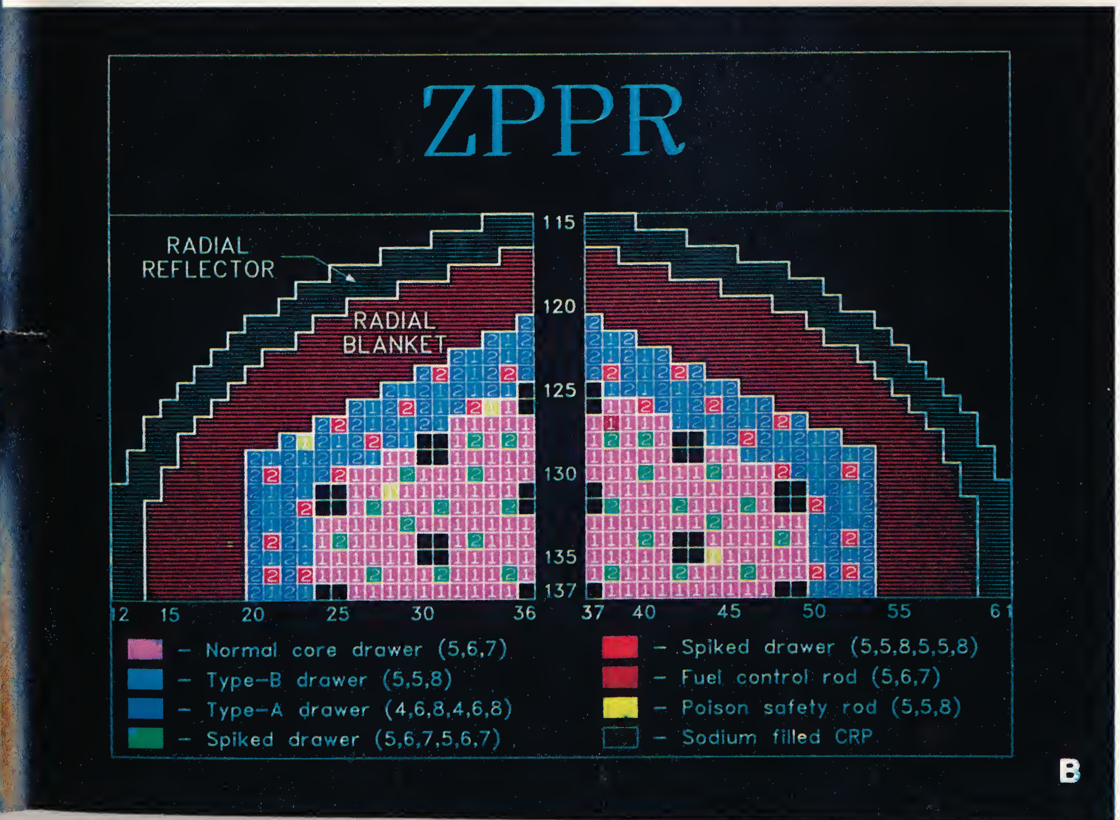


A



B





A. *Correlation matrix table revealing statistical correlations between variables associated with offshore oil and gas leases. The warm colors indicate a relationship in which both variables increase or decrease. The cool colors represent a relationship in which both variables change in opposing directions.*

B. *Used in nuclear safeguards studies, this simulation represents a cross-section of the fuel drawer arrangement in the core of a fast critical research reactor. It shows the amount and type of nuclear fuel present in the core. Colors indicate the type of fuel; numbers indicate a one- or two-plate drawer of fuel.*


Rayter
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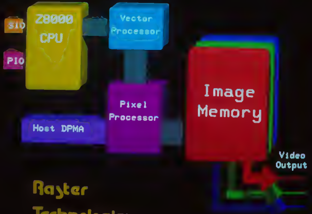
Model
One

MODEL ONE
SYSTEM BLOCK DIAGRAM



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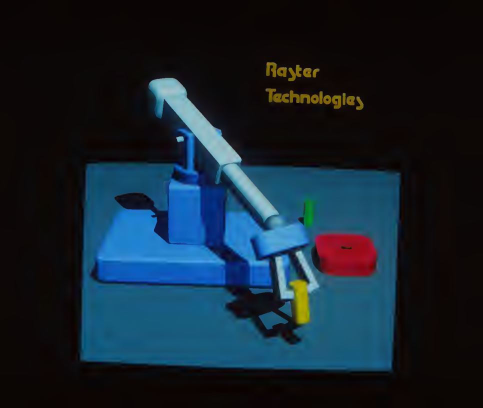
Raster
Technologies